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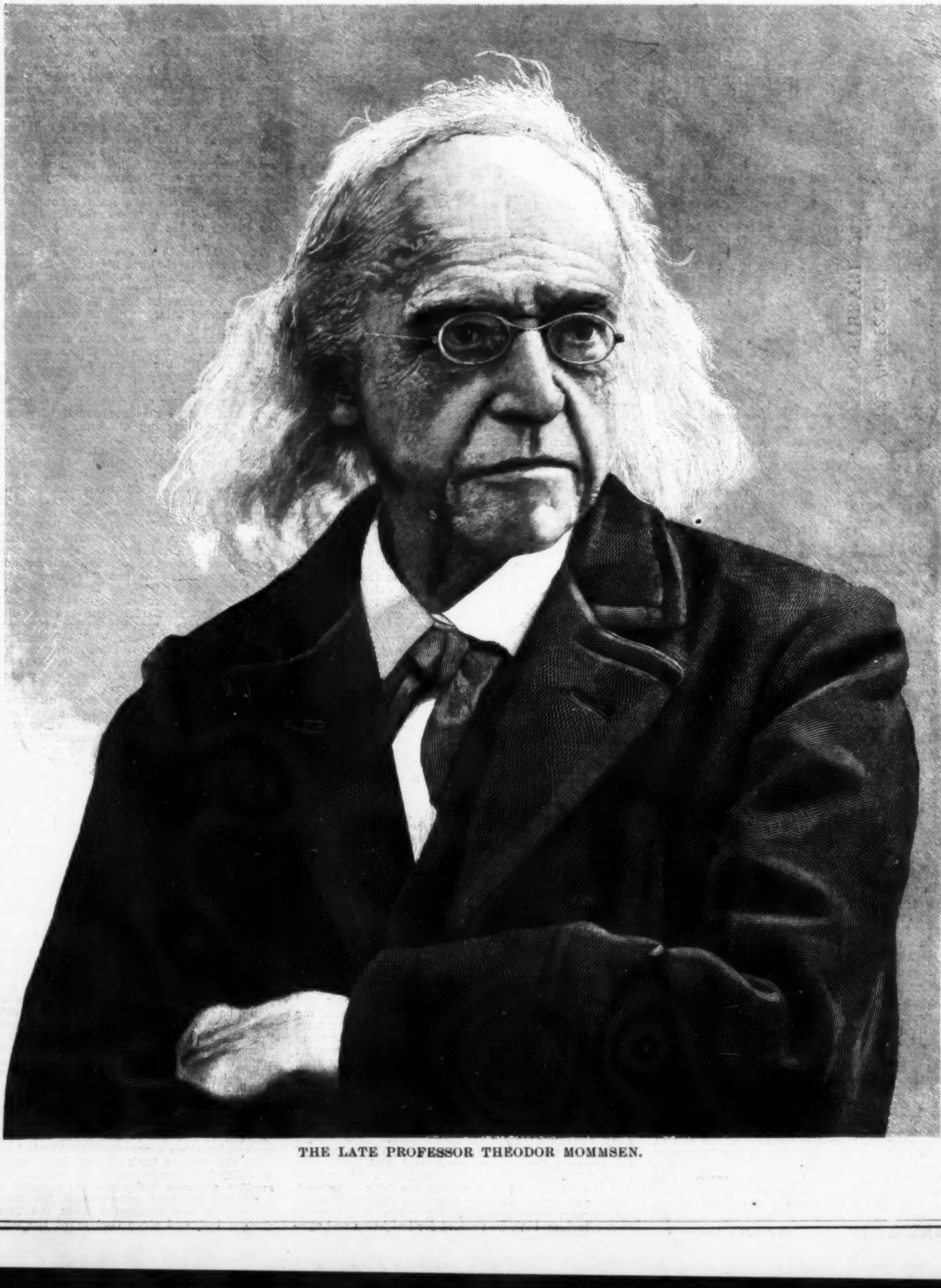


THE LATE PROFESSOR THEODOR MOMMSEN.

THEODOR MOMMSEN.

Death has again taken away a man who not only filled a very prominent position among the learned of his own countrymen, but who was regarded as one of their number, and ungrudgingly recognized as one of their most illustrious representatives by the leaders of thought and culture throughout the world. Though he had reached an age such as nature grants only to the most favored of her children, the news of his serious illness and of his death a few days later came as a shock of surprise to the public. Only slowly and reluctantly could men face the fact that Theodor Mommsen also was no more.

Mommsen was the son of a pastor, and was born on the 30th of November, 1817, in the little town of Garding, in Schleswig. From 1838 to 1843 he studied law and history at the University of Kiel, and at the beginning of his career entered with firm step into the domain where he was afterward to win his most signal triumphs and make his splendid and permanent contributions to the literature of all time. The Roman Constitution formed the subject of his dissertation for his doctor's degree, and while working as a private teacher, after leaving the university, he published an essay on the part taken by the Roman tribes in the administration. This was followed a year later by his "Oscan Studies." From 1844 to 1847 he devoted his time to making searching studies from original sources in Italy and France, and in the autumn of 1848, exactly fifty-five years ago, he commenced his illustrious academical career as extraordinary professor of law at Leipzig.

Here he not only occupied himself with the affairs of ancient nations, but, as was frequently the case in his later life, took an active interest in the political questions of his own time. Before entering on his duties at Leipzig, he had, for a short time, edited in Rendsburg the Schleswig-Holsteinische Zeitung, a journal of pronounced liberal tendencies. At Leipzig he took an active part in the movement for liberty in 1848-49, especially in the latter year. He was first suspended and finally dismissed in 1850 after a long investigation, went to Switzerland, like many of his companions in misfortune, and was appointed professor of Roman law at the University of Zurich in 1852.

It is a proof of the estimation in which Mommsen's literary work was held even at that early period, and also an indication of freedom from prejudice on the part of the Prussian government, which it but too rarely displayed at that time, that Mommsen was called from his professorship at Zurich, in 1854, to fill a similar position at Breslau. This action of the government deserves grateful recognition, for by it Mommsen was preserved for Germany. Four years later, when he left Breslau for Berlin, he at the same time changed the faculty of law for the faculty of philosophy, and was appointed professor of ancient history. The cause of this change was the appearance of his most widely known work, his classical "Roman History" (1st ed., 1854-5). This work has not escaped the attacks of the critics; for the author was charged with permitting himself too much freedom of treatment, and breathing too much modern spirit into the old forms. But Mommsen was no Philistine in literary matters. He was not content merely to view the annals of the Roman historians through the spectacles of a philologist, but handled his material as a politician, and by so doing he succeeded in arousing the interest of his readers, and in opening the way to a proper understanding of old Roman history. This is the great, the permanent merit of his book, a merit which no carping criticism can impair. The fifth volume of the "Roman History" appeared in 1885. Some notes among Mommsen's literary remains are all that exists of the fourth volume.*

The number of the published works of the indefatigable writer is very great. In the department of Roman law his most important work is the "Roman Constitutional Law" (1899), in three volumes, to which must be added the "Summary of Roman Constitutional Law" (1893), "Roman Criminal Law" (1899), and his edition of the digests in the first volume of the "Corpus Juris Civilis" (8th ed., 1899). He also published various works on inscriptions, and, in collaboration with Henzen, Vols. 1 to 15 of the "Corpus Inscriptionum Latinarum," and took part in the publication of the "Monumenta Germaniæ Historica." During the long period from 1874 to 1895, Mommsen was secretary to the Berlin Academy of Science and subsequently remained in close touch with that institution. The same may be said of his connection with the philosophical faculty. When forced by reason of old age to abandon his lectures and seminary exercises, he regularly attended the meetings of the faculty. He was untiring in his literary labors up to the day of his rapid and fatal illness.

From 1873 to 1882 Mommsen sat in the Prussian Chamber of Deputies, being a member, first of the National Liberal party, and afterward of the Liberal Union. In 1881 he took his seat in the Reichstag, where he remained till 1884. Here he also was at first a member of the Liberal Union, subsequently joining the party of progress. Coburg was his district. He was also for many years a member of the Berlin Town Council. His parliamentary activity, particularly in the Reichstag, brought him into frequent collision with Prince Bismarck. An incautious utterance in a speech at Charlottenburg even resulted in a charge of libel. He was, however, acquitted, as he maintained that the incriminatory expression "policy of swindling" was not aimed at Bismarck or anyone else. "I cannot help feeling," said Bismarck, when Mommsen, on the 24th of January, 1882, reproached him with wishing to act the part of a constitutional majordomo, "that the illustrious scholar has so completely buried himself in the affairs of nations two thousand years behind us in point of time, that his eyes have been blinded to the sunlight of the present day."

Mommsen was not backward in the expression of his political convictions when occasion seemed to call for it. In November, 1901, on the occasion of the call of the Catholic professor Martin Spahn to the University of Strasburg, he entered the lists to champion the cause of absence of prejudice in scientific research, and his action elicited universal approval. It will be remembered that only a few months ago he attempted to prepare the way for a reconciliation of English and German public feeling, and the opinion was freely expressed that Mommsen the politician could not add to the fame of Mommsen the scholar. He has not at any rate been able to shake it.

At midnight on the 29th of October, Mommsen was seized with a severe attack of apoplexy, which paralyzed his left side and was pronounced by the doctors to be dangerous to his life. Early in the morning of the 1st of November the old man, who had nearly completed his 86th year, was released by death without recovering consciousness. High and low, Germans and foreigners, the German Emperor at the head, had inquired concerning his condition.

Mommsen was made a member of the Paris Academy in 1895, honorary citizen of Rome in 1896, and he obtained the Nobel prize last year. He was thus highly esteemed in foreign countries, and he will be honored for all time in his native country as an ornament to German learning. The Emperor expressed this conviction in fitting terms to Mommsen's widow.—Illustrirte Zeitung.

* What is nominally the fourth volume is in reality a separate work.

ANCIENT CHALDEAN IRRIGATION.

So persistently does modern literature, both technical and general, force itself upon the attention of the world, that things of the past are almost crowded out. Men of the present day are too apt to forget great deeds wrought and great works done in early days, and proud in the enjoyment of privileges bestowed by modern engineering science, are almost persuaded that they, as individuals, have had some share in creating, or are in some way responsible for, the marvels of the twentieth century. Even if it were right for those of the rank and file to identify themselves in this facile way with the results of modern science, it would still be a mistake to believe that human intelligence in itself is essentially greater than it was thousands of years ago. Knowledge has certainly increased, bringing in its train vastly increased resources, so that a task may now be accomplished in a few days that formerly would have required as many years. Yet, many works that are now regarded as masterpieces of modern engineering skill have been equaled, if not surpassed, in nearly forgotten ages. Within recent months volumes have been written upon Nile irrigation works in papers of all kinds, from serious technical journals down to fashion books, probably leading the average man or woman to form the opinion that no works of similar magnitude were ever before conceived or realized. It is forgotten, or has never been known, by such people that basin irrigation, as practised in Egypt and elsewhere 7,000 years or more ago, is even now the most efficacious method of treating some lands, and that perennial irrigation, sometimes thought to be a modern invention, is of great antiquity. Moreover, some of the most gigantic engineering works of former times are unknown to many people, even by repute. As examples of comparatively unknown achievements, we may cite some remarkable engineering works of which the remains are still to be found in Yemen, the ancient home of the Sabæans. One of these is the ruined masonry dam at Mareb, or Sheba, the original capital of the country. This work is supposed to have been built by Lokmân in the year 1700 B. C., and according to M. d'Arnaud, a well-known French traveler, it consists of a great masonry wall, 2 miles long and 175 paces wide, connecting two hills. In another account, it is said to be 2 miles long by 500 feet thick by 120 feet high. Its object was the storage of water for irrigation, and regulation was effected by sluices at different heights, so that supplies might be maintained irrespective of the water levels in the reservoir. At Hirran, in the same region, there exist the ruins of an ancient masonry dam, connecting two spurs of a hill, this work being 150 yards long, 20 feet high, and wide enough to permit the passage of a carriage and pair along the top. There are also the remains of several deep wells, whose object was evidently the provision of water for the garrison of an early fortress.

Interesting as these remains undoubtedly are, the ancient irrigation works of Chaldea are still more noteworthy, and they acquire additional importance from the fact that the Bagdad railway, which it is proposed shall be built along the Euphrates and Tigris valleys, will have the effect of throwing open the country to Western civilization. Bagdad, the ancient capital of the Kaliphs, inaptly named "The Abode of Peace," lies in the midst of a desolate waste that was once a densely populated and highly-cultivated region. To the north, at Dura, was the upper intake of the ancient Nahrwân Canal, and there the golden image was set up by Nebuchadnezzar. Tel Alig, where died the Emperor Julian, lies in ruins a few miles to the south of Dura. Next come Opis, once the wealthiest emporium of the East; the ruins of Ctesiphon, where the great arch of Nausherwan's palace still stands in witness to the faded magnificence of the Sassanian kings; Cuxana, where Xenophon and his 10,000 Greeks commenced their historic retreat through a land cut up by innumerable canals; and lastly Babylon, "The Gate of God," once captured after some smart hydraulic engineering by the Persian besiegers.

On one side of the Tigris the delta was formerly irrigated by the great Nahrwân Canal and an extensive system of smaller canals, and between the Tigris and the Euphrates the country was watered by main and branch canals running more or less parallel with the river, and by a vast network of canals extending from river to river. The lives and property of cultivators were secured on one hand by the Median Wall, and on the other by the towering bank of the Nahrwân Canal, these ramparts being guarded by soldiers to prevent the incursions of wandering tribes. The river Tigris, that silent witness of the rise and fall of Assyrian power, flows to-day past the ruins of Nineveh, and breaking through the Hamrin Hills, enters the high-lying plateau at their feet, and passes in a trough some 60 feet deep over a shingly bed, the velocity of the stream being 7.5 feet per second, and its average width 1,500 feet. Near Opis, the Atheim River flows into the Tigris, and at this point the delta is entered. The character of the river bed then changes, shingle giving way, first to argillaceous marls, and then to finer alluvium, both well suited for irrigation and agriculture. Below Bagdad the Dyâleh River joins the Tigris, and thenceforward the fine alluvial deposits of the delta, accompanied by salt, continue to the sea. The annual flood commences about the end of the winter season, and is augmented with the advance of spring and summer by the melting of snows in the hills, the supply of water increasing as temperature rises. Still, as the rainfall is generally insufficient for agriculture, uniform and adequate supplies cannot be insured without irrigation works. That part of the country with which we are chiefly concerned is the delta of the Tigris, in which Opis is the natural starting point for a great system of irrigation. Above this place the engineers of a remote period established the intakes of their most important canals—the Nahrwân on the eastern bank, the Ishaki and others on the western bank. In order to insure the better supply of water to the canals, rubble weirs were formed across the Tigris down stream of the canal heads, very much as the Asyût barrage has been built below the head of the Ibrahimiyeh Canal on the Nile. Each of the great canals acted as the feeder for a huge system of smaller channels serving the country on either side of the river.

When these canals were constructed, the Tigris flowed in its ancient bed, and Opis stood on the eastern bank. Reference will be made later to the transference of the river to its present course, an event that brought desolation to one of the most populous and fruitful countries in the whole world. The Nahrwân, known in its upper reaches as the Katul-el-Kesrawi, the "Trench of the Kaiser," originally served the purpose of supplying a large system of canals between Opis and a point some hundred miles below, where the main canal rejoined the Tigris. Like many canals that require silt clearances at intervals, the Nahrwân had two heads. The upper head, about 40 miles in length, took water from the Tigris just above Dura, where are the remains of the Kantara Resasa, a large masonry weir built of massive stones clamped with lead. The lower head at Kudesieh had two intakes each 360 feet wide, and a grand regulator, the ruins of which are now in the modern bed of the river. At the junction of the canal heads once stood a flourishing city, and the massive barrage known as Kantaret-el-Kesrawia, the Bridge of the Kaiser, the remains of which still exist.

The total length of the Nahrwân Canal was about 250 miles. For the first few miles its channel was 65 feet wide by nearly 50 feet deep. It then attained an average width of nearly 400 feet, while the depth was reduced to about 36 feet. Below the Dyâleh River, which carried a large part of the supplies, the canal was reduced in width to 130 feet, but when Sifweh was passed it again widened out to about 360 feet. It is interesting to compare the dimensions of this giant waterway with the largest of Egyptian canals—the Rayan el-Menufiyeh, of which the width is 174 feet, and the depth 20 feet in flood, and 10 feet in summer. Speaking last year of this canal, Sir Benjamin Baker said that even in the exceptionally dry time of June, 1900, it was carrying a volume of water one and a fourth times greater than the Thames in mean flood. Hence in flood time it would be quite capable of conveying two and a half times the quantity of water carried by the Thames. But the Nahrwân Canal had a section four times that of the Menufiyeh, and its maximum capacity was fully ten times that of the Thames in mean flood. Just below the confluence of its two main feeders, the Nahrwân Canal is severed by the Atheim River, and has disappeared for a length of more than a mile. In ancient times injury by this river was guarded against by some remarkably well-designed engineering works at the foot of the Hamrin Hills. A masonry dam, about 800 feet long by 55 feet high, was built across the river, connecting the spurs of two hills, and masonry regulators were provided at the same point. By these means the waters of the Atheim were divided between two canals, the Nahr Batt and the Nahr Rathan, irrigating the country on either side of the river, and discharging into the Nahrwân through masonry regulators. The Nahr Rathan has long since disappeared. Below the ruins of Heyme, the Nahrwân has been totally destroyed for a distance of several miles by the diversion of the Tigris. In consequence of the injuries already described, other damage naturally followed. The tail waters of the Khalis Canal, being no longer swept along by a powerful current, filled the Nahrwân channel with silt, and it ultimately became cultivated land, through which passes the modern Khalis, serving a system of smaller channels. Between the ruins of Bakuba and Sifweh, the ancient course of the Nahrwân runs parallel with the Dyâleh River, but the canal itself has practically disappeared. Along this stretch the Nahrwân was formerly at such a level that it was able to deliver water to the higher lands below Sifweh, whereas the Dyâleh could only serve the low-lying lands. Beyond Sifweh are the ruins of the Beldei Dam, once holding up the waters of the Dyâleh and delivering them into the Nahrwân, but in the present day the river effects a junction with the Tigris.

Between Beldei and the point at which the Nahrwân finally discharges into the Tigris, there are numerous remains of ancient cities, main regulators, and branch canal heads, all testifying to the wonderful prosperity and civilization that characterized this now deserted region. Even with the scanty materials available, it would be easy to paint a glowing picture of the ancient wealth and prosperity of Chaldea, but we prefer to turn to actual records. Accounts written nearly a thousand years ago described the Nahrwân Canal as "flowing amid continuous extensive villages, date-groves, and well-cultivated lands, and finally discharging into the Tigris a little below Badrai." It is further said, "It had well-constructed buildings on its banks, it flows amid cultivation and villages, and, in like manner, many branches emanating from it irrigate the country between it and the east bank of the Tigris. These copious branches reach unto the Tigris."

On the western bank of the Tigris were the Ishaki and Nahriyat canals, and a vast system of other and smaller channels irrigating the country above flood level, but of these watercourses few traces remain. Their ruin was compassed when the Tigris left its ancient bed, and since that event the modern Dijeil

Canal was made, the term Dijeil being an old name of the Tigris, and its application to the canal system signifying that the new waterways were intended to fulfill the duties of the departed river. But the "modern" Dijeil Canal is now an ancient work. The present state of a bridge over the Dijeil, at Harbeh, shows how the canal has withered away. The bed is choked with huge mounds of silt, and the little water that flows barely fills a single arch of the old bridge. This is typical of the whole country, where decay and desolation are everywhere apparent. Viewed from the high ground above Opis, the land presents an almost inconceivable picture of wreck. The dismembered walls of the great city lie at the feet of the beholder, while the mounds of many other cities and towns are dotted like islands over a vast plain, utterly bare of vegetation, and smooth as a calm sea. This aspect of the country clearly denotes bygone disaster, a sudden and overwhelming onslaught, prostrating everything in its way. Commander Felix Jones, in his interesting Memoirs, says that "the Tigris, as it anciently flowed, is seen to have left its channel and to have taken its present course through the most flourishing portion of the district, severing in its mad career the neck of the great Nahrwân artery, and spreading devastation over the whole district around. Towns, villages, and canals, men, animals, and cultivation, must thus have been engulfed in a moment, but the immediate loss was doubtless small compared with the misery and gloom that followed. The whole region, for a space of 240 miles, averaging about 18 miles in breadth, was dependent on the conduit for water, and contained a population so dense, if we may judge from the ruins and great works traversing it in its whole extent, that no spot on the globe perhaps could excel it. Of those who were spared to witness the sad effects of the disaster, thousands, perhaps millions, had to flee to the banks of the Tigris for the immediate preservation of life, as the region at once became a desert where before were animation and prosperity." These views as to the cause of the ruin that overtook Chaldea are confirmed by examination of the plans and levels of the country. When the main stream of the Tigris deserted its ancient bed, sweeping away the Nahrwân regulator, cutting out a new channel for itself, eating into one feeder canal, and finally biting away a huge slice of the Nahrwân itself, the ruin of that magnificent work and of all its dependent channels was complete and irreparable. Above Sifweh the canal was abandoned, and only the lower reaches were thenceforward used. The dam at Beldei was strengthened, and a new head for the Nahrwân was constructed at the same place. Little benefit could follow the execution of these works, for the scanty supplies of the Dyâleh River were utterly inadequate, and no help was afforded from the plenitude of the Tigris. On the western bank the damage was little less disastrous. The old river bed silted up, the weirs that had held up the waters to feed the main canals no longer fulfilled their function, the canals dwindled away, and the region became a desolate waste. As the ruin of the Nahrwân was the greatest blow the country has ever received, so its restoration would be the greatest blessing that could be bestowed.

A scheme for the restoration of the ancient irrigation works on the Tigris has recently been propounded by Sir William Willcocks in a lecture delivered at a meeting of the Khedivial Geographical Society, Cairo. The rehabilitation of Chaldea is a most interesting subject, and discussion is opportune at the present time in view of the attention that is being devoted to the Bagdad railway scheme. With politics, Sir William Willcocks disclaims all connection. His ambition is simply that of an irrigation engineer, "to see ten blades of grass growing where none are growing to-day." His lecture is addressed solely to the engineering and economic problems involved in the recreation of Chaldea by the restoration of her ancient irrigation works. The first works recommended are the reopening of the ancient channel of the Tigris, and the construction of a weir at the head of each branch, so that both the ancient and the modern Tigris may be maintained and properly controlled, just as the branches of the Nile are maintained and controlled by the Cairo barrage. The Nahrwân Canal would be renewed and remodeled throughout, and provided with a new head. The treatment of the Atheim River would be of similar character to that already described, and it is significant that Sir William Willcocks, one of the most competent hydraulic engineers of the twentieth century, has no improvement to suggest upon the principle adopted by Chaldean engineers who flourished thousands of years ago. A new course is proposed, to carry the canal round the bend of the Tigris opposite Opis, and powerful spurs would prevent further encroachment by the river. A super-passage is proposed for the Khalis Canal to prevent interference with the Nahrwân; the Dyâleh River would serve the low-lying lands in the direction of Bagdad, while the higher lands would again be watered from the Nahrwân, flowing at a high level in a new channel traversing a new course. This chain of works could be executed within reasonable time, and although not covering everything necessary, would suffice as the basis upon which the complete system of irrigation could be rebuilt. To enable a precise estimate of cost to be made, information would necessarily have to be gathered by experts—such as could only be attained by months, and perhaps years, of patient observation and field work. By way of affording a general idea as to the financial success of a modern irrigation system, a preliminary estimate of costs and results was presented by Sir William Willcocks, from which we abstract the following figures:

It is stated that the area of the lands requiring nothing but water to yield an immediate return is 1,280,000 acres, and that the cost of the necessary works would be about £8,000,000. On this basis the cost of irrigation works would not exceed £7 per acre. The value of the irrigated land is taken at £30 per acre, and the return for an expenditure of £8,000 000 is therefore calculated at £38,400,000. The swamped and generally barren tract lying between the Tigris and Euphrates, and away from the immediate vicinity of the former river, has ah area of 1,500,000 acres, and the necessary expenditure is estimated at £13,000,000, the value of the reclaimed and irrigated land being put at £15 per acre. Consequently, the return to an irrigation company is estimated at £22,000,000. It is further stated that if the rates prevailing in India were adopted, every figure representing cost should be divided by 4, and those expressing land values should be divided by 2. On this basis the figures would stand thus:

District.	Acres.	Cost of Works.	Value of Land.
Upper Chaldea ..	1,280,000	£2,000,000	£19,000,000
Lower Chaldea ..	1,500,000	3,250,000	11,000,000
Totals	2,780,000	£5,250,000	£30,000,000

In the present state of knowledge with regard to Chaldea, it is impossible to express any definite opinion upon these figures, but it may be remarked that, as compared with records afforded by practical work of a similar nature in other Eastern countries, they appear to be perfectly reasonable. Further, it may be observed that every acre of land reclaimed and brought under cultivation would bring revenue to the new railway, for Chaldea lies in the very path of this projected communication between the East and the West. In turn, the railway would augment the value of the land by opening up new markets for agricultural produce. In this connection it cannot be too strongly urged that railway and irrigation schemes should be regarded as mutually dependent, for it would be a lamentable mistake if the railway were to traverse a barren part of the country, leaving regions that are destined to include cultivated lands without transport facilities.

We have now briefly glanced at the ancient irrigation works of Chaldea, and the suggestion made for their rehabilitation. Conceived by old-world engineers of high intelligence and ability, these great undertakings constituted the source of the teeming wealth that made Chaldea the object of all Eastern conquerors, and her possession the crown of their conquests. As their inauguration was followed in ages long since past by wonderful fertility, flourishing population, and boundless wealth, so would their restoration be followed, recreating the ancient glories of Chaldea, so that, as of old, men might journey from the East—and even from the West—to find a resting place in the plain of Shinar.—The Builder.

INTERESTING DISCOVERIES AT OXFORD.

An interesting discovery has been made at Queen's College, Oxford. During the long vacation important works have been in progress, including the installation of the electric light throughout the college and the overhauling of a part of the drainage. In introducing the electric light it was convenient to pass a cable through the crypt underneath the apse of the chapel, which was erected in the northeast corner of the great quadrangle in 1714. On opening the crypt it was found to contain on a stone rest a leaden casket with the remains of the founder, Robert Eglesfield, chaplain and confessor to Philippa, Queen of Edward III., from whom the college derives its name. Eglesfield died in 1349, aged forty-three, and was buried in the college chapel. Cut deep in the lead, on the top of the casket, are the words, "Reliquiæ Fundatoris," a peculiarity being that the letter "d" is turned backward. No date accompanies the inscription. In front were coffins of Provosts Brown, Fothergill, and Collinson, and in a recess to the right on entering were the coffin of Provost Smith and the remains of Provost Haltom. The latter was buried under the old chapel in 1704, but his coffin was removed when the new chapel was built a few years later.

There were also in the crypt some curious memorials which had formerly been placed in the old chapel, and at its demolition were probably for safety transferred to this spot. One was broken stone, to which was attached a small brass representing a tun or barrel, with a musical note known as a "long" upon it, with the capital letter "R." This is a rebus of the name "Langton." Robert Langton having been a doctor of laws, and nephew of Bishop Langton, who at one time was provost of the college; Robert built the large ante-chapel to the old chapel in the year 1518. The stone had also upon it a depression in which the head of the figure of Langton had rested. In the muniment room of the college was a brass which in the last century was believed to be that of Robert Eglesfield, the founder of the college, but archæologists described it as of later date, and no doubt correctly so. The head of this brass fits into the depression in the stone on which is the rebus, and it is certainly that of Robert Langton.

Another interesting discovery was a brass representing the figure of a man, with an inscription below. The features and the details of the inscription are all rubbed quite flat. This has been identified as the memorial of Nicholas Hyenson, fellow of the college in 1477. In addition, there was found a stone with an inscription of "Radulphus Hamisterrey, Master of the University College." Above the inscription in the depression of the stone there was evidently originally a figure, but this has disappeared. In the crypt were the three gravestones, which formerly rested on the floor of the old chapel, of Provost Airay (provost, 1599-1616), Provost Christopher Potter, and Provost Langbaine. Airay's stone has a brass plate with an inscription upon it, and the other stones are engraved with the arms of the provosts. In the identification of these memorials an engraving by Burghers representing the ground-plan of the old chapel was found useful. This plan also facilitated the determination of the position of the west front of the ante-chapel, which was disclosed in the excavations made for drainage purposes in the line of the path leading from the great gate of the college to the chapel passage.

The drainage works also disclosed some feet below the surface two passages, one in the front quadrangle and the other in the back, the object of which at first seemed doubtful. It was conjectured they might have belonged to an older building occupying the site of the present college. Mr. James Parker (president of the Oxford Architectural and Historical Society), who was consulted, satisfied himself that the tooling on some of the stones corresponded with the tooling of some of the stones which were laid when the college was rebuilt. It is now looked upon as certain that the passages were conduits leading to large blind wells intended to receive the surface water from the college roofs and quadrangles, and that the conduits were made so large to hold the flood water in case of an exceptional rainfall.

The crypt has been closed, the leaden casket and coffins being left as they were found. The remains of Provost Haltom, from which the coffin had fallen, have been deposited in an oak casket, and the gravestones have been placed in the ante-chapel. The brasses, found in the crypt, with the stones to which they are attached, are fixed in the wall of the apse, together with two other brasses that have long been preserved in the muniment room. They will form an additional feature of interest in the chapel, the foundation-stone of which was laid on February 6, 1714, the dedication taking place on All Saints' Day, five years later. The illuminated windows in the chapel by Van Ling (1635) are in good preservation, and were removed from the first chapel. They depict scenes in the life of Christ. The westernmost windows are earlier, and two of them bear the date 1518, of Robert Langton's ante-chapel. Some tiles of an ornamental character were discovered *in situ* near the western entrance of the old chapel, some of them adorned with the same rebus as is on the brass which formed part of Langton's memorial.—London Times.

THE SALT, SALT SEAS.

How many of our readers who have just returned from the seashore, where they have disported in the briny surf and browned themselves upon the sands of the beach, know why the seas are salt and what percentage of salt they contain? How many of you have asked yourselves or others where the salt comes from, or why in fact the ocean is salt, and not the rivers which flow into it, at least not perceptibly so? Would you be surprised to learn that all the salt comes from the mountains, hundreds, aye thousands, of miles from the sea? That the swift-flowing brooks, the shallow, broad-bosomed streams, and even the large rivers, which bear upon their surface immense rafts and ships, are all salt bearers, that is, they carry in solution salt so finely divided that it is not sensible to our taste? And that this has been going on since the beginning of the world's existence?

Our common table salt—sodium chloride, as it is scientifically called—is a mineral, rather a salt of a mineral, and is contained in the rocks; the action of the atmosphere, the frosts, disintegrate it, and the melting snows and rains wash it from its resting place; holding it in solution, they carry it ever onward to the sea. From this receptacle there is no escape, no outlet. True, a circulation there is, in the great oceans; but, while it is continuous and confined within bounds, it serves only to distribute the salty solution more evenly throughout the mass. By the action of the sun's rays the sea supplies the rising mists, which, wafted over the land by breezes from the sea, are condensed and fall upon the thirsty earth in gentle rain. But what of the salt? Being too heavy to be lifted by the sun's rays, it remains behind.

During the centuries of the earth's existence, this process has been going on continuously, and the descending rains, in their return to their original homes, have washed tons upon tons, not only of silt, but of salt, into the sea, and left it there until by the sense of taste we become conscious of its presence. All rivers, however, do not find their way to the sea or to the great oceans. There are numerous inland lakes which are nothing more or less than sunken valleys with no outlet, filled with the water which the descending rains pour into them.

Not a few of these lakes are so large, that is, they cover so much space, that they are dignified with the name sea, and the streams which feed them are called rivers. Of such we have only to cite the Great Salt Lake in Utah and the Dead Sea in Palestine.

These two very salt lakes have one characteristic in common—between fifty and sixty miles above them are situated smaller lakes, the Utah Lake in the first instance, and the Sea of Galilee in the latter case, both of which contain fresh water, and solely because they have outlets; in fact, they discharge their overflow through a river, in both instances called the Jordan River, into the lower lakes, whence the sun distills the water and leaves the salt. With this their similarity ends; for while the Great Salt Lake is 4,250 feet above the level of the Pacific Ocean, the Dead Sea is 1,295 feet below the surface of the Mediterranean Sea, representing the deepest depression on the earth's surface. The superficial areas covered by the waters of these lakes are slowly becoming less.

So dense are the waters of the Great Salt Lake, that the inhabitants of the region, with very little exertion and without any mechanical assistance, supply themselves and others with salt through the natural evaporation of the water. Besides the Jordan, so intimately connected with hallowed story, there are not a few other streams which pour their salt-laden waters into the Dead Sea. Moreover, springs without number bubble up fresh, pure water into its heavy brine.

You would hardly conceive of obtaining drinking water from such a locality, and the few inhabitants who still linger in the region near the southern terminus of the dread lake are, in the long dry season, sorely put to it for fresh water, and they are forced to call upon these springs to supply their needs, which they do in quite an original way. The springs are easily discovered, for the fresh water, being lighter, bubbles up to the very top from considerable depths below; and in several places a stream of some volume, as if from an artesian well at the bottom, spouts up to the top, spreading out upon the surface before it is actually absorbed in the brine.

The boatmen in search of water row to these spouting springs, with the ancient goatskin flask, and prepare to fill them. Now see how it is done. Grasping the neck of the skin tightly in both hands, so as to close it completely, they dive, head first, holding the flask before them, into the rising column of fresh water. Having descended a little way, they suddenly open the mouth of the empty skin, into which the fresh water as quickly rushes, filling it instantly. By closing it as before, the divers retain the fresh

and exclude the salt water, and struggle again to the surface, which, by the way, does not require much effort, for the water is so heavy with salt that it is rather a struggle to get down into it than to come to the top.

We have already spoken of the circulation going on constantly in the great oceans, which mixes the waters up, and one would naturally suppose that it would also distribute the salt evenly throughout the whole mass. Were all the seas equally open or accessible to this circulatory influence, there is no doubt that this would be the result. That it is not the case is proven by the examination of water taken from various places, which shows widely differing percentages of salt. That long inlet known as the Red Sea, into which no circulatory current ever flows, bears suspended in its sluggish waters 0.042 per cent of salt. The Mediterranean, despite the fierce current that constantly flows into it from the Atlantic through the Straits of Gibraltar, the effect of which, however, cannot be far-reaching, in that 2,320 miles of sea, regardless too of the great volume of fresh water pouring into it from Europe and Asia through the Black Sea and from Africa by way of the noble Nile—this greatest of inland seas, owing to the excessive African heat, shows a percentage of 0.0385, while the broad Atlantic contains but 0.03675 per cent of salt. In the English Channel only 0.0326 per cent can be found. The Black Sea, which is practically an upper lake for the Mediterranean, into which it discharges constantly, has only 0.012 per cent of salt.

Ensconced in its cold berth in the regions of the North, where little evaporation takes place, the chill waters of the Baltic Sea carry but 0.006 per cent of salt. Of the inclosed seas, the Caspian, the receptacle of large volumes of Asiatic water, contains only 0.0055 per cent, while the Dead Sea carries a burden of 24 per cent, and the Great Salt Lake 26 per cent of saline solution.

EXPERIMENTS WITH A NEW TYPE OF COMPOUND LOCOMOTIVE IN ITALY.

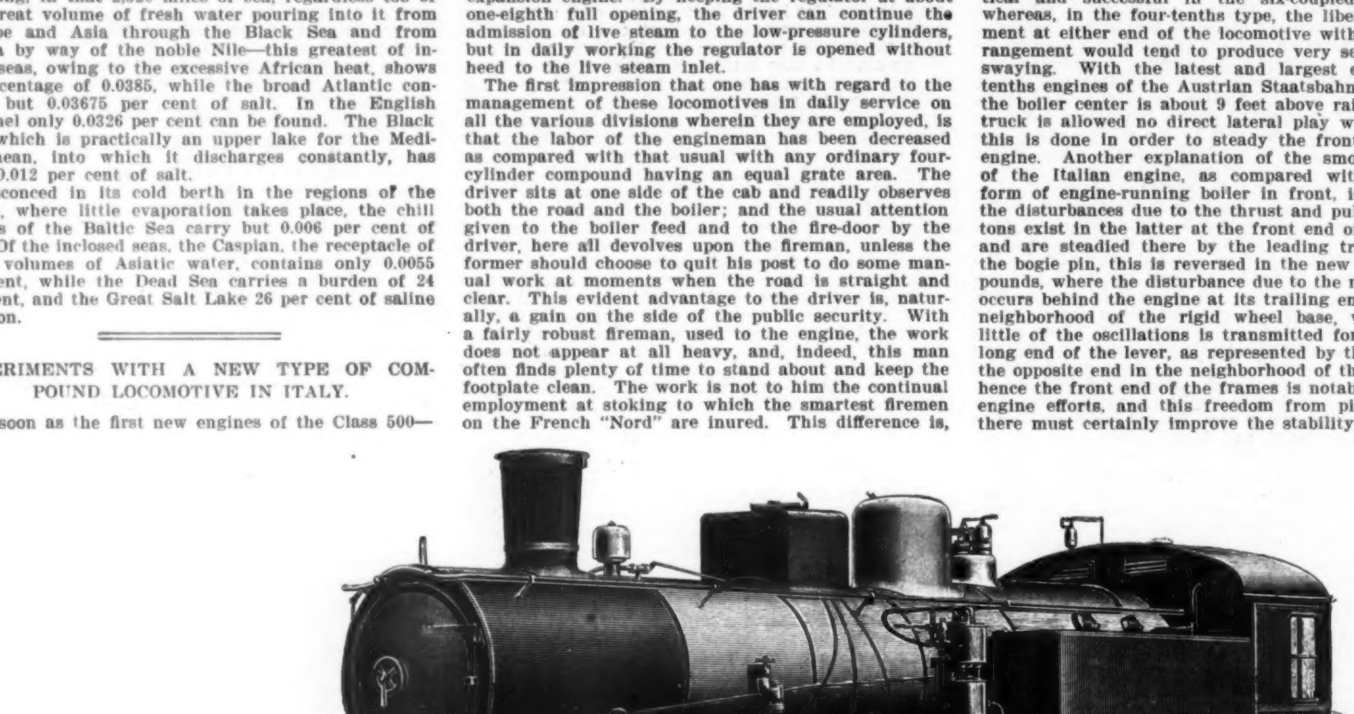
As soon as the first new engines of the Class 500—tube, 120 millimeters, reaching from the bottom of the blast pipe to the top of the chimney, and the other was a simple pipe. The first is still in an experimental stage.

Both pipes are cast with a cinder trap for smoke-box cleaning, but the arrangement does not so far appear to answer the demand for that excessive simplicity which is always needed at this end of a boiler.

The cab sides, formerly open, are now closed, and the door is in front. It is possible that new locomotives may have the door placed on the left side of the cab, and a very capacious coal bunker situated at the opposite side.

It will be remembered that in starting the regulator always uncovers a hole in the seating of the semi-balanced throttle valve, and by means of a pipe this high-pressure steam is introduced into the receiver through a sort of slide valve on the extension of the high-pressure piston valve rod. Consequently all is automatic and the engine is worked precisely as a single-expansion engine. By keeping the regulator at about one-eighth full opening, the driver can continue the admission of live steam to the low-pressure cylinders, but in daily working the regulator is opened without heed to the live steam inlet.

The first impression that one has with regard to the management of these locomotives in daily service on all the various divisions wherein they are employed, is that the labor of the engineman has been decreased as compared with that usual with any ordinary four-cylinder compound having an equal grate area. The driver sits at one side of the cab and readily observes both the road and the boiler; and the usual attention given to the boiler feed and to the fire-door by the driver, here all devolves upon the fireman, unless the former should choose to quit his post to do some manual work at moments when the road is straight and clear. This evident advantage to the driver is, naturally, a gain on the side of the public security. With a fairly robust fireman, used to the engine, the work does not appear at all heavy, and, indeed, this man often finds plenty of time to stand about and keep the footplate clean. The work is not to him the continual employment at stoking to which the smartest firemen on the French "Nord" are inured. This difference is, employed. This result is the extraordinarily smooth movement noticeable at the front end of the engine, traveling there being freer from oscillations than in many four-wheeled coaches. This smooth movement on the footplate has often been compared to that of a Pullman car, but it is, perhaps, still freer. The difference of riding in the cab of the Italian engine and the cab of an Atlantic type locomotive is very great—speed of train and radius of curves being equal in both cases. The hard, short, disagreeable thump which characterizes the Atlantic or four-tenths type on entering a short radius curve is replaced in the Meridionali engine by an undulating sway in one direction, followed by a slower reaction in the other. The lessened fatigue to the men on the engine means also some lessened extent of wear to the rails, for the tangential momentum of the engine entering curves is transmitted more gradually to the sides of the bogie-wheel flanges. The long pendulum levers of the swinging cradle, uncontrolled by lateral springs, are practical and successful in the six-coupled locomotive, whereas, in the four-tenths type, the liberty of movement at either end of the locomotive with such an arrangement would tend to produce very serious lateral swaying. With the latest and largest express four-tenths engines of the Austrian Staatsbahnen, in which the boiler center is about 9 feet above rails, the bogie truck is allowed no direct lateral play whatever, and this is done in order to steady the front end of the engine. Another explanation of the smooth running of the Italian engine, as compared with the usual form of engine-running boiler in front, is that while the disturbances due to the thrust and pull of the pistons exist in the latter at the front end of the engine and are steadied there by the leading truck through the bogie pin, this is reversed in the new Italian compounds, where the disturbance due to the motive power occurs behind the engine at its trailing end, all in the neighborhood of the rigid wheel base, whence very little of the oscillations is transmitted forward to the long end of the lever, as represented by the frames at the opposite end in the neighborhood of the bogie pin; hence the front end of the frames is notably free from engine efforts, and this freedom from piston thrusts there must certainly improve the stability of the loco-



FOUR-CYLINDER COMPOUND EXPRESS LOCOMOTIVE, MERIDIONALI RAILWAY, ITALY.

numbered from 5002 to 5017, the Exhibition engine, No. 3701, then taking the initial number 5001—were put to working fast trains, they were able to haul loads of from 51 per cent to 67 per cent greater than those of "180" and "180 bis," averaged together, with an increase in coal consumption of from 6 to 11 per cent, but with an economy in ton-kilometers of 25 per cent.

During the present year the new engines have been given heavier work, being now permitted to travel at the maximum speeds allowable, and the following notes relate to the service of the latest locomotives in their present condition.

Referring to the mechanical arrangement of the present series of locomotives compared with the experimental engine of the Exhibition, now "No. 5001," it may be noted that the boiler is shorter, so economizing some weight at the cylinder end. The piston valve of the low-pressure cylinder has double-headed pistons, and the steam chest is somewhat longer than the cylinder, so that the steam passages between the two low-pressure cylinders have been simplified. It should be noted that the crossed passages of the high-pressure cylinders, as cast at Breda's, Milan, were not considered to present any difficulty either in the casting, or the cleaning, or the machining.

A number of fixed nozzles of different sizes were cast at Florence for the blast pipe, after ascertaining the best area by trial, but these have now been rejected in favor of variable nozzles. A great number of trials were made on engines with different forms of wing nozzles, commencing at first with flat wings, with slightly convex wings, and then others with a deeper convexity until the radius of the wing was finally made to form a perfect circle, 150 centimeters diameter, when the nozzle was set at a medium area. One blast pipe of annular section was formed by a long undoubtedly, in some part due to the Italian coal which comes from England and, being fairly clean, enables the fireman to fire less frequently and to keep the cab in better trim.

The only disadvantage in running cab in front is just that which is usual to all tank engines when proceeding backward, namely, the reflection of the light when firing against the front windows—a really most objectionable effect; but this has since been very simply remedied by a square foot or two of sheet iron hooked on to the support of the reversing screw, so that it screens the fire light from the driver's eyes. This was first installed by the men themselves, while others which have since been made in the running shed shops consist of a rather more workmanlike arrangement of hinged screens for use at night time. With these screens the opening of the fire-door has less effect in interfering with the driver's view than have the ordinary gage or reversing screw lamps used on engines running boiler in front as customary. Another objection formulated against this type of locomotive was that with a broken gage glass the safety of everyone would be at stake. As a matter of fact, what then takes place is exactly the reverse of that which was presumed, for in two seconds from the moment of closing the water cocks all steam disappears from the cab, going with a rush through the open windows and ventilators in the rear. A couple of gage glasses which burst on the road during one trip caused no other inconvenience than the wetting of the occupants of the cab and the steaming of the front windows for an instant.

The most remarkable result obtained in the new locomotive relates to a matter having no connection with the working of the engine, and due merely to the coincidence of placing the footplate over the bogie, and also to some extent to the particular form of bogie motive when upon curves. In following the windings along the banks of the Arno from Florence, in the direction of Arezzo, the curves are very frequent, and descend to 350 meters in radius, and yet, once the engine is going at 50 to 55 miles per hour, no reduction in speed is made when passing these bends, which often lie between a steep embankment on one side and the walls of houses on the other—just where any spreading of the rails under the engine wheels would be a very disagreeable matter, as can only be fully appreciated when observed from the front end of an engine while traveling at that speed.

In the front of the cab there is a platform, shielded by a sort of dashboard, serving to carry the lamps. This platform is precisely similar to those at the ends of vestibuled corridor cars, the door of the engine cab being in front. It may be of interest to record that the sensation of riding here with the gliding motion of the engine is something superior to automobilism on dusty roads. The noise, the dust, the odor and the warmth of all engine cabs are entirely absent. It is even possible to make written observations above the front buffers with considerable ease, and to converse without raising the voice, the only sounds audible being the regular tapping of the rail joints by the bogie wheels, and the whistle of the wind through the lamp chimney. In this position, in front of the cab, a cushion of air is formed, tending to force the rider forward toward the dashboard.

During forthcoming trials advantage will be taken of this new standing position on the locomotives to measure the atmospheric head resistance, with anemometers variously placed, and the results will on this account be undoubtedly of more value than heretofore, since the cab has in its form some approximation to the end of a railway carriage. The personal observations alone that can be made in front of the cab

suffice to upset many preconceived notions as to the effect of head winds and side winds.

At present there exist even on the Meridional lines two methods of working the steam expansively—this being on the Rome-Florence section, and occasionally also on the Bologna-Milan stretch—that is, to give an admission to the cylinders of 15 per cent while running on the level, and from 20 to 25 per cent on heavy gradients, the regulator being about half to three-quarters open; but a different plan is employed upon the level line from Milan to Venice, the drivers there being recommended never to cut off to below 40 per cent admission, and for less requirements to work with the regulator, which latter usually varies from one-third to two-thirds of full openings on the level stretches. By this latter means the consumption of water is appreciably reduced. Opinion as to which of the two is the best method of working, however, differs greatly in Italy as elsewhere, for with the very large four-cylinder compounds of the Austrian State Railways it is customary to open the regulator three-quarters, and to cut off to rarely ever less than 55 per cent while hauling a train load of not much over 240 tons, thus differing very little from French methods for compound engine running.

The foregoing description of the new series of engines and their manner of working in daily service can now be supplemented with the following notes upon the latest results obtained from them:

A train ran from Florence to Orte, 148 miles, last April, with a load of 297 tons net, or with locomotive included, 403½ tons gross. The interesting part of the journey lies between Florence and Ponticino, a distance of 44 miles, all upon up gradients; but the greatest test for the engine with such a dead load occurs between Montevarchi and Laterina, a continuous grade of 1 in 100 to 1 in 88. The train started from Florence forty-six minutes late, steam being admitted to the cylinders for a few seconds at 70 per cent of the stroke, and then with an earlier cut-off of 30 per cent, while the regulator given was first one-third, then one-half of the full opening, the boiler pressure being 213.34 pounds per square inch. Later on the cut-off allowed was made 28 per cent, and, still later on, arrived at the bank mentioned, 30 per cent, with the regulator half open, and subsequently admission was increased to 33 per cent, while the boiler pressure fell first to 199.12 pounds, and then recovered to 206.23 pounds, and, finally, at the top of the hill, the pressure attained full boiler load, 213.34 pounds. The average speed on the up grade was, as will be observed from the record, about 27 miles per hour when under full way; firing while on the level and on the up grades took place at intervals of five and four minutes, with eight to ten rounds from the shovel.

After passing Arezzo in the direction of Orte there are no heavy adverse gradients. Toward the end of the run, between Orvieto and Chiusi, one of the injectors failed, and thus with a fire that had been allowed to burn out, the speed, even on the falling grade, was not remarkable. The coal consumed for the actual distance of 142.8 miles was three tons, or nearly 46.1 pounds per actual train-mile. These engines have no spark meshing, but it was easy to observe in the darkness during the latter part of this run that the few sparks emitted were so small as to be extinguished within a few feet of the chimney top.

At the time of the journey the running department made it obligatory to pilot all express trains going toward Orte when, at Florence, they exceeded 300 tons weight, although the locomotive department always considered that the engines might take 320 tons without double heading. But, with the loads to be hauled by one single compound locomotive on other sections having been progressively increased, there was reason to believe this could be done in regular service with express trains on the more difficult line between Firenze and Orte; and so about a month after the run above mentioned an attempt was made by Signor Greppi, of the head traction department at Bologna, to convince the drivers that a pilot engine could be dispensed with altogether for such work, and the load was thereupon increased in successive trains to 314 tons, 332 tons, and 333 tons. That the engines were successful is shown by the fact that the average speed made while the engines were under full way up the incline between Montevarchi and Laterina was nearly 30 miles per hour instead of only about 27 miles per hour, as previously. The Italian season is now ended and the service is light, but at its recommencement trains will often have to be doubled unless the comparatively small compounds of the Meridionali can be made to haul loads of American proportions, and this can only be obtained by continued progressive trials. Eventually the single-headed trains on this latter section, and in the direction of Orte, will in all probability arrive at a coach load of 350 tons, but in the opposite direction it is doubtful if 360 or 370 tons will be exceeded, on account of the bank between Orvieto and Chiusi, while on the Milano to Venezia stretch it is also probable that the coach load will attain 450 tons—equal to an American gross load of 612 tons—long before these engines will have been replaced by a more powerful series of the same type, such as in a few years will be a necessity to satisfy traffic requirements.—Engineer.

A WOVEN CARTRIDGE BELT.

For over a year past, while experiments with the new Springfield rifle, model of 1903, have been in progress, the Bureau of Ordnance of the War Department has been engaged in devising a substitute for the present regulation double-loop cartridge belt, which is not adapted to carrying the ammunition for the new rifle, for the reason that the cartridges are carried in slips of five each. The Department itself was engaged in experiments at Rock Island Arsenal for producing a russet-leather carrier, and meanwhile it invited various manufacturers to experiment with other materials.

Last winter a board of officers, consisting of Capt. Foltz, of the Cavalry, Capts. Rawson and Munson, of the Infantry, and Capt. Dickson, of the Ordnance, was organized, and assembled at Sandy Hook to experiment with the different carriers there presented. None of them was found to be entirely suitable, but experiments were continued, and finally the Anson Mills Woven Cartridge Belt Company, of Worcester, Mass., produced a suitable woven carrier and suspenders, which the Department adopted for future use, not only with the new Springfield rifle requiring clips, but also for the single cartridges used by that portion of the army which may continue temporarily to use the Krag.

The new belt is 3½ inches wide, and has nine pockets, each of the proper size for holding two clips, giving a capacity of ninety rounds in the entire belt. One

FIG. 3.—THE WOVEN CARTRIDGE BELT.

pocket, however, will be used for carrying the first-aid package, thus reducing the number of cartridges carried to eighty.

In the accompanying illustrations there are shown, in Fig. 1, a front view of a soldier equipped with the new carrier and suspender, in the act of inserting a clip of cartridges in the magazine of the new Springfield rifle; in Fig. 2, a back view, showing the belt with its pockets filled with clips; and Fig. 3, showing the carrier detached from the suspenders.

Both the carrier and the suspenders are formed wholly of woven fabric, the only sewing being on the points of the pocket flaps, and at the ends of the belt, which are further finished with metal end-pieces. On the suspenders there is no sewing whatever. The pockets are integral with the belts, and are formed by weaving only, the threads of which they are composed being continuously interwoven with the body of the belt. This enables the manufacturer to produce pockets absolutely uniform in size, not only on a single belt, but on all belts that may be woven, and which are separable from the belt only by destroying the fabric. Neither of these features is obtainable on any belt formed by sewing one piece of material to another.

The fabric of both belt and suspenders is woven from a specially hard-twisted cotton yarn of great durability, which is dyed in the same shade of khaki color as the service uniform.

The flaps covering the pockets are of separate pieces of fabric eyeleted to the body of the belt. They are provided with a strong ball-and-socket glove fastener, by means of which the flap may be buttoned over the pocket, thus holding securely in place the clips or cartridges therein.

The ends of the belts are provided with fasteners which engage eyelets, set at intervals in the body of the fabric, to enable the soldier to accommodate the length of the belt to his girth. Near the lower edge of the belt are fixed a series of eyelets, from which the canteen and the haversack may be suspended; and near the upper edge are eyelets through which pass the hooks of the suspenders.

The suspenders are of the same kind of woven fabric as the belt itself. The web resting on the shoulder is 2¼ inches wide; the supporters attached to this, which are of fabric one inch wide, end in hooks which engage the eyelets in the belt. Three adjustments are provided, two in front and one in the back, thus enabling the tallest or the shortest soldier to bring the belt itself to the proper position about his waist. To prevent the suspenders slipping off the shoulders, one of the branches of each of the two front lugs may be hooked in an eyelet on the further side of the belt, as shown in Fig. 1, and the belt may then be worn unbuckled to afford ease in strenuous marching.

All the metal parts are made of brass, and are bronzed to the same shade as the buttons on the service uniform. The buttons on the pockets are embossed with the regulation device of the eagle.

The carrier is shown in the illustration with the regulation hook fastener of the present service belt; but, before being issued to the army, each belt will be equipped with a new form of buckle, which the Department will produce at Rock Island Arsenal.

The total weight of the new carrier, exclusive of the buckle, is fifteen ounces, and that of the suspenders is eleven ounces.

In bringing the belt to its present perfect form, great assistance has been given the manufacturer by the Bureau of Ordnance, particularly by Capt. Dickson, who has made many valuable suggestions.

FIG. 1.—FRONT VIEW.

FIG. 2.—BACK VIEW.

SOLDIER WEARING THE NEW WOVEN CARTRIDGE BELT FOR THE U. S. ARMY.

THE COST OF MOUSE-POWER.

The Scotsman has dug up an old pamphlet in which is given an account, by one David Hatton, of his investigation and practical employment of mouse-power. The American Machinist republishes the account. The following is extracted from Hatton's narrative:

"In the summer of the year 1812 I had occasion to be in Perth, and, when inspecting the toys and trinkets that were manufactured by the French prisoners in the depot there, my attention was involuntarily attracted by a little toy house with a wheel in the gable of it that was running rapidly round, impelled by the insignificant gravity of a common house mouse. For a shilling I purchased house, mouse, and wheel. Inclosing it in a handkerchief, on my journey homeward I was compelled to contemplate its favorite amusement. But how to apply half-ounce power, which is the weight of a mouse, to a useful purpose was a difficulty. At length the manufacturing of sewing thread seemed the most practicable." Mr. Hatton had one mouse that ran the amazing distance of eighteen miles a day, but he proved that an ordinary mouse could run ten and one-half miles on an average. A halfpenny's worth of oatmeal was sufficient for its support for thirty-five days, during which it ran 736 miles. He had actually two mice constantly employed in the making of sewing thread for more than a year. The mouse thread mill was so constructed that the common mouse was enabled to make atonement to society for past offenses by twisting, twining, and reeling from 100 to 120 threads a day, Sundays not excepted. To perform this task, the little pedestrian had to run ten and one-half miles, and this journey it performed with ease every day. A halfpenny's worth of oatmeal served one of these thread mill culprits for the long period of five weeks. In that time it made 3,350 threads of 25 inches, and as a penny was paid to women for every hank made in the ordinary way, the mouse, at that rate, earned 7 shillings and sixpence a year. Taking sixpence off for board and allowing 1 shilling for machinery, there was a clear yearly profit from each mouse of 6 shillings. Mr.

Hatton firmly intended to apply for the loan of an old empty cathedral in Dunfermline, which would have held, he calculated, 10,000 mouse mills, sufficient room being left for keepers and some hundreds of spectators. Death, however, overtook the inventor before his marvelous project could be carried out.

THE ATOMIC THEORY.*

ONE hundred years ago, on October 21, 1803, John Dalton gave this society the first announcement of his famous atomic theory. It was only a slight preliminary notice, a mere note appended to a memoir upon another subject, and it attracted little or no attention. In 1804 Dalton communicated his discovery to Dr. Thomas Thomson, who at once adopted it in his lectures, and in 1807 gave it still wider publicity in a text book. A year later Dalton published his "New System of Chemical Philosophy," and since then the history of chemistry has been the history of the atomic theory. To celebrate Dalton's achievement, to trace its influence upon chemical doctrine and discovery, is the purpose of my lecture. It is an old story, and yet a new one; for every year adds something to it, and the process of development shows no signs of nearing an end. A theory that grows, and is continually fruitful, can not be easily supplanted. Despite attacks and criticisms, Dalton's generalization still holds the field; and from it, as from a parent stem, spring nearly all the other accepted theories of chemistry.

Every thought has its ancestry. Let us briefly trace the genealogy of the atomic theory. In the very beginnings of philosophy men sought to discover the nature of the material universe, and to bring unity out of diversity. Is matter one thing or many? Is it continuous or discrete? These questions occupied the human mind before recorded history began, and their vitality can never be exhausted. Final answers may be unattainable, but thought will fly beyond the boundaries of knowledge to bring back, now and then, truly helpful tidings.

To the early Greek philosophers we must turn for our first authentic statements of an atomic theory. Other thinkers in older civilizations, doubtless, went before them—perhaps in Egypt or Babylonia—but of them we have no certain knowledge. There is a glimpse of something in India, but we cannot say that Greece drew her inspiration thence. For us Leucippus was the pioneer, to be followed later by Democritus and Epicurus. Then, in lineal succession, came the Roman, Lucretius, who gave to the doctrine the most complete statement of all. In the thought of these men the universe was made up of empty space, in which swam innumerable atoms. These were inconceivably small, hard particles of matter, indivisible and indestructible, of various shapes and sizes, and continually in motion. From their movements and combinations all sensible matter was derived. Except that the theory was purely qualitative and non-mathematical in form, it was curiously like the molecular hypothesis of modern physics, only with an absolute vacuum where an intermediary ether is now assumed. This notion of a vacuum was repellent to many minds; to conceive of a mass of matter so small that there could be none smaller was unreasonable; and hence there arose the interminable controversy between plenists and atomists which has continued to our own day. It is, however, essentially a metaphysical controversy, and some writers have ascribed it to a peculiar distinction between two classes of minds. The arithmetical thinker deals primarily with number, which is, in its nature, discontinuous, and to him a material discontinuity offers no difficulties. The geometer, on the other hand, has to do with continuous magnitudes, and a limited divisibility of anything in space is not easy for him to conceive. But be this as it may, the controversy was one of words rather than of realities, and its intricacies have little interest for the scientific student of to-day. It is always easier to reason about things as we imagine they ought to be, than about things as they really are, and the latter procedure became practicable only after experimental science was pretty far advanced. The Greeks were deficient in physical knowledge, and, therefore, their speculations remained speculations only, mere intellectual gymnastics of no direct utility to mankind. They sought to determine the nature of things by the exercise of reason alone, whereas science, as we understand it, being less confident, seeks mainly to co-ordinate evidence and to discover the general statement which shall embrace the largest possible number of observed relations. The man of science may use the metaphysical method as a tool, but he does so with the limitations of definite, verifiable knowledge always in view. Intellectual stimulants may be used temperately, but they need not be discarded altogether.

From the time of Lucretius until the seventeenth century of our era, the atomistic hypothesis received little serious attention. The philosophy of Aristotle governed all the schools of Europe, and scholastic quibblings took the place of real investigation. All scholarship lay under bondage to one master mind, and it was not until Galileo let fall his weights from the leaning tower of Pisa that the spell of the Stagirite was broken. Experimental science now came to the fore, and it was seen that even Aristotelian logic must verify its premises. The authority of evidence began to replace the authority of the schools.

Early in the seventeenth century the atomic philosophy of Epicurus was revived by Gassendi, who was soon followed by Boyle, by Newton, and by many others. One other important step was taken also. Boyle, in his "Sceptical Chymist," gave the first scientific definition of element, a conception which was more fully developed by Lavoisier later, but which received its complete modern form only after Davy had decomposed the alkalies and shown the true nature of chlorine. Without this preliminary work of Boyle and Lavoisier, Dalton's theory would hardly have been possible. An elementary atom can be given no real definition unless we have some notion of an element to begin with. But the strongest impulse came from Newton, who accepted atomism in clear and unmistakable terms. Coming before Newton, Descartes had rejected the atomic hypotnesis, holding that there could be no vacuum in the universe, and making matter essentially synonymous with extension. True, Descartes, in his famous theory of vortices, imagined whirling particles of various degrees of fineness; but they were not atoms as atoms and molecules are now conceived. It may be dangerous to pick out landmarks in history and to assert that such and such a movement began at such and such a time. Nevertheless, we may fairly say that the turning point in physical philosophy was Newton's discovery of gravitation, for that indicated mass as the fundamental property of matter. For any given portion of matter which we can segregate and identify, extension is variable and mass is constant; when that conclusion was established, the dominance of atomism became inevitable. Boyle, Newton and Lavoisier were legitimate precursors of Dalton, but whether Boscovich should be so considered is more than doubtful. His points of force were too abstract a conception to admit of direct application in the solution of real problems. Dalton certainly owed nothing to Boscovich, and would just as surely have developed his theory had the brilliant Dalmatian never written a line.

To Boyle and Newton the atomic hypothesis was a question of natural philosophy alone; for, in their day, chemistry, as a quantitative science, had hardly begun to exist. Attempts were soon made, however, to give it chemical application, and the first of these which I have been able to find was due to Emanuel Swedenborg. This philosopher, whose reputation as a man of science has been overshadowed by his fame as a seer and theologian, published in 1721 a pamphlet upon chemistry, which is now more easily accessible in an English translation of relatively recent date.* It consists of chapters from a larger unpublished work, and really amounts to nothing more than a sort of atomic geometry. From geometric groupings of small, concrete atoms, the properties of different substances are deduced, but in a way which is more curious than instructive. Between the theory and the facts there is no obvious relation. The book was absolutely without influence upon chemical thought or discovery, and, therefore, it has escaped general notice. It is the prototype of a class of speculative treatises, considerable in number, some of them recent, and all of them futile. They represent efforts which were premature, and for which the fundamental support of experimental knowledge was lacking.

In 1775, Dr. Bryan Higgins, of London, published the prospectus of a course of lectures upon chemistry, in which the atomic hypothesis was strongly emphasized. It was still, however, only a hypothesis, quite as ineffectual as Swedenborg's attempt, and it led to nothing. Dr. Higgins recognized seven elements; earth, water, alkali, acid, air, phlogiston and light; each one consisting of "atoms homogeneal," these being "impenetrable, immutable in figure, inconvertible," and all "globular, or nearly so." He speculated upon the attractions and repulsions between these bodies, but he seems to have solved no problem and to have suggested no research. William Higgins, on the other hand, whose work appeared in 1789, showed more insight into the requirements of true science, and had some notions concerning definite and multiple proportions. His conception of atomic union to form molecules was fairly clear, but the distinct statement of a quantitative law was just beyond his reach. In 1814, however, when Dalton's discoveries were widely known and accepted, Higgins published a reclamation of priority.† In this, with much bitterness, he claims to have completely anticipated Dalton, a claim which no modern reader has been able to allow. In Robert Angus Smith's "Memoir of John Dalton and History of the Atomic Theory,"‡ the work of Bryan and William Higgins is quite thoroughly discussed, and, therefore, we need not consider the matter any more fully now. We see that atomic theories were receiving the attention of chemists long before Dalton's time, although none of them went much beyond the speculative stage, or was given serviceable form. They were dim foreshadowings of science—nothing more.

In order that a new thought shall be acceptable, certain prerequisite conditions must be fulfilled. If the ground is not prepared, the seed cannot be fruitful; if men are not ready, no harvest will be reaped. Only when the time is ripe, only when long lines of evidence have begun to converge, can a new theory command attention. Dalton's opportunity came at the right moment, and he knew how to use it well. Elements had been defined; the constancy of matter was established; pneumatic chemistry was well developed, and great numbers of quantitative analyses awaited interpretation. The foundations were ready for the master builder, and Dalton was the man. His theory could at once be tested by the accumulated data, and when that had been done it was found to be worthy of acceptance.

It is not my purpose to discuss in detail the processes of Dalton's mind. The story is told in his own notebooks, which have been given to the public by Roscoe and Harden,§ and it has been sufficiently discussed by others. We now know that Dalton was thoroughly imbued with the corpuscular ideas of Newton, and that, when studying the diffusion of gases, he was led to the belief that the atoms of different substances must be different in size. Upon applying this hypothesis to chemical problems, he discovered that these differences were in one sense measurable, and that to every element a single, definite, combining number, the relative weight of its atom, could be assigned. From this, the law of definite proportions logically followed, for fractions of atoms were inadmissible; and the law of multiple proportions, which Dalton worked out experimentally, completed the generalization. The conception that all combination must take place in fixed proportions was not new, and, indeed, despite the objections of Berthollet, was generally assumed; but the atomic theory gave a reason for the law and made it intelligible. The idea of multiple proportions had also occurred, although incompletely, to others; but the determination of atomic weights was altogether original and novel. The new atomic theory, which figured chemical union as a juxtaposition of atoms, co-ordinated all of these relations, and gave to chemistry, for the first time, an absolutely general quantitative basis. The tables of Richter and Fischer who preceded Dalton, dealt only with special cases of combination, but they established regularities which rendered easier the acceptance of the new and broader teachings. The earlier atomic speculations were all purely qualitative, and incapable of exact application to specific problems; Dalton created a working tool of extraordinary power and usefulness. Between the atom of Lucretius and the Daltonian atom the kinship is very remote.

Dalton was not a learned man, in the sense of mere erudition, but perhaps his limitations did him no harm. Too much learning is sometimes in the way, and clogs the flight of that imagination by which the greatest discoveries are made. The man who could not see the forest because of the trees was a good type of that scholarship which never rises above petty details. It may compile encyclopedias, but it cannot generalize. In some ways, doubtless, Dalton was narrow, and he failed to recognize the improvements which other men soon introduced into his system. The chemical symbols which he proposed were soon supplanted by the better formulæ invented by Berzelius, and his views upon the densities of gases were set aside by the more exact work of Gay Lussac, which Dalton never fully appreciated. As an experimenter he was crude, and excelled by several of his contemporaries; his tables of atomic weights, or rather equivalents, were only rough approximations to the true values. These defects, however, are only spots upon the sun, and in no wise diminish his glory. Dalton transformed an art into science, and his influence upon chemistry was never greater than it is to-day. The truth of this statement will appear when we trace, step by step, the development of chemical doctrine. The guiding clue, from first to last, is Dalton's atomic theory.

Although Dalton first announced his theory in 1803, the publication of his "System" in 1808 marks the culmination of his labors. The memorable controversy between Proust and Berthollet had by this time exhausted its force, and nearly all chemists were satisfied that the law of definite or constant proportions must be true. The idea of multiple proportions was also easily accepted; and as for the combining numbers, they, after various revisions, came generally into use. The atomic conception, however, made its way more slowly, for the fear of metaphysics still governed many acute minds. Davy especially was late in yielding to it, but in time even his conversion was effected. Thomson, as we have already noted, was the earliest and most enthusiastic disciple of the new system, and Wollaston, although cautiously preferring the term "equivalent" to that of atomic weight, made useful contributions to the theory. These names mark the childhood of the doctrine, before its vigorous growth had thoroughly begun.

The development of the atomic theory followed two distinct lines, the one chemical, the other physical, in direction. On the chemical side the leader was Berzelius, who began in 1811 the publication of his colossal researches upon definite proportions. At first he seems to have been influenced by Richter rather than by Dalton, but that bias was only temporary. For more than thirty years Berzelius continued these labors, inventing symbols, establishing formulæ and determining atomic weights. He, above all other men, made the atomic theory applicable to general use, a universal tool suited to practical purposes. Turner, Penny, Erdmann and others did noble work of the same order, but Berzelius overshadowed them all. Throughout his long career he was almost the dictator of chemistry.

It was on the physical side, however, that the theory of Dalton was most profoundly modified. First came the researches of Gay Lussac, who in 1808 showed that combination between gases always took place in simple relations by volume, and also that all gaseous densities were proportional either to the combining weights of the several substances, or to rational multiples thereof. In 1811 Avogadro generalized the new evidence, and brought forward the great law which is now known by his name. Equal volumes of gases, under like conditions of temperature and pressure, contain equal numbers of molecules. Mass and volume were thus covered by one simple expression, and both were connected with the weights of the fundamental atoms. Avogadro, moreover, distinguished clearly between atoms and molecules, a distinction which is of profound importance to chemistry, although it is not always properly appreciated by students of physics. The molecule of to-day, which is usually, but not always, a cluster of atoms, is identical with the atom of the pre-Daltonian philosophers; while the chemical unit represents a new order of divisibility which the ancients could never have imagined. A molecule of water was easily conceived by them, but its decomposition into smaller and simpler particles of oxygen and hydrogen, the chemical atoms, was far beyond the range of their knowledge. That the distinction is not always borne in mind by physicists is illustrated by the fact that in Clerk Maxwell's article "Atom," in the "Encyclopedia Britannica," Dalton is not even mentioned, and that the phenomena there selected for discussion are molecular only. Maxwell was surely not ignorant of the difference between atoms and molecules, but his knowledge had not reached the point of complete realization. His thought was of molecules, and so Maxwell unconsciously neglected the real subject of his chapter, the atom. Of late years many essays upon the atomic theory have been written from the physical side, and few of them have been free from this particular ambiguity. At first, a similar error was committed by chemists, who paid small attention to Avogadro's law,

* The Wilde lecture before the Manchester Philosophical Society, delivered May 19, 1903.

* "Some specimens of a work on the Principles of Chemistry with other treatises." London, 1847. Originally published at Amsterdam, in Latin.

† "Experiments and Observations on the Atomic Theory and Electrical Phenomena." By William Higgins, Esq., etc., Dublin, 1814.

‡ Memoirs of the Literary and Philosophical Society of Manchester, Second Series, Volume 13, 1856.

§ "A New View of the Origin of Dalton's Atomic Theory," etc. By Sir Henry E. Roscoe and Arthur Harden. London, 1896.
See also Debus, in Zeits. Physikal. Chem., Bd. 20, p. 359, and a rejoinder by Roscoe and Harden in Bd. 22, p. 241.

and so the latter failed to exert much influence upon chemical thought until more than forty years after its promulgation. The relation discovered by Dulong and Petit in 1819, that the specific heat of a metal was inversely proportional to its atomic weight, was more speedily accepted; but even this law did not receive its full application until many years later. To apply either of these laws to chemical theory involved a clearer discrimination between atomic weights and equivalents than was possible at the beginning. A long period of doubt and controversy was to work itself out before the full force of the physical evidence could be appreciated. Mitscherlich's researches upon isomorphism were more fortunate, and gave immediate help in the determination of atomic weights and the settlement of formulæ. For the moment we need only note that the chemical atom was the underlying conception by means of which all these lines of testimony were to be unified.

From Dalton and Gay Lussac to Frankland and Cannizzaro was a time of fermentation, discussion, and discovery. In chemistry, contrary to the saying of the Preacher, there were many new things under the sun, and some of the discoveries were most suggestive. First it was found that certain groups of atoms could be transferred from compound to compound, almost as if they were veritable elements; and radicles such as ammonium, cyanogen, and benzoyl were generally recognized. I say "groups of atoms" advisedly, for as such they were regarded, and they could hardly have been interpreted otherwise. Then came the discovery of isomerism—of the fact that two substances could be strikingly different, and yet composed of the same elements in exactly the same proportions. This was only explicable upon the supposition that the atoms were differently arranged within the isomeric molecules, and it led investigators more and more to the study of chemical or molecular structure. Without the atomic theory the phenomena would have been hopelessly bewildering; with its aid they were easy to understand, and fertile in suggestions for research. Still another link in the chain of chemical reasoning was forged by Dumas, when he proved that the hydrogen of organic compounds was often replaceable, atom for atom, by chlorine. Sometimes the replacement was complete, sometimes it was only partial, and the latter cases were the most significant. In acetic acid, for example, one, two, or three fourths of the hydrogen could be successively replaced, but the last fourth was permanently retained. Hydrogen, then, was combined in acetic acid in two different ways, one part yielding its place to chlorine, the other being unaffected. This behavior was soon found to be by no means exceptional; indeed, it was very common, and it opened a new line of attack upon the problems of chemical constitution. The existence of radicles, the formation of isomers, and the substitution of one element by another, were facts which strengthened the atomic theory and seemed to be incapable of reasonable interpretation upon other terms. Their connection with one another, however, was not well understood, and wearisome discussions preceded their co-ordination under one general law.

With the tedious controversies which distracted chemists between 1830 and 1850, we have nothing now to do; they were important in their day, but they do not come within the scope of the present argument. Theory after theory was advanced, prospered for a time, and then decayed; and chemical literature is crowded with their fossil remains. Each one, doubtless, indicated an advance in knowledge, but each one also exaggerated the importance of some special set of relations, and so over-shot the mark. During this period, however, Faraday discovered the law of electrolysis which is now known by his name, and the chemical equivalents were thereby given another extension of meaning. The electrochemical theories of Berzelius had fallen to the ground, but Faraday's law came as a permanent addition to the physical side of chemistry.

During the sixth decade of the nineteenth century, two important forward steps were taken. The kinetic theory of gases gave new force to Avogadro's law, and made its complete recognition by chemists necessary. Atoms, molecules, equivalents, and atomic weights needed to be more sharply defined, and in this work many chemists shared. Berzelius had proposed a system of atomic weights which differed, except in value taken for its base, but little from the one now in use. This was abandoned for a table devised by Gmelin, in which the laws of Avogadro and of Dulong and Petit were almost if not entirely ignored. Laurent and Gerhardt attempted to reform the system, but it was left for Cannizzaro, in 1858, to succeed. By doubling some of the currently accepted atomic weights, order was introduced into the prevailing chaos, and the chemical constants were brought into harmony with the physical laws. The modern atomic weights and our present chemical notation may be dated from this time, even though the preliminary anticipations of them were neither few nor inconspicuous.

The second great step forward was accomplished through the labors of several men. Frankland and Kekulé were foremost among them, but Couper, Odling, Williamson, Wurtz and Hofmann all contributed their share to the upbuilding of a new chemistry, of which the doctrine of valency was the cornerstone. A new property of the chemical atom was brought to light, and structural or rational formulæ became possible. Each atom was shown to have a fixed capacity for union with other atoms, a capacity which could be given numerical expression; and from this discovery important consequences followed. An atom of hydrogen unites with one other atom only; the atom of oxygen may combine with two; that of nitrogen with three or five; while carbon has capacity for four. All unions of atoms to atoms within a molecule are governed by conditions of this order, and the limitations thus imposed determine the possibilities of combination in a given class of compounds. In organic chemistry the conception of valency has been most fruitful, and it has shown the prophetic power which is characteristic of all good theories. It explains radicles and isomers; it predicts whole classes of compounds in advance of their actual discovery; and it has guided economic investigations from which great industries have sprung. The former partial theories regarding chemical constitution fell into their proper places under the new generalization, for that was broad enough to comprehend them all. All constitutional chemistry depends upon this property of the atoms, and any other adequate foundation for it would be difficult to find.

I have said that the discovery of valency explained the phenomena of isomerism. Indeed, it enabled chemists to foresee the existence of new isomers, and it established the conditions under which such compounds could exist. And yet, in one direction at least, its power was limited, and substances were found which the theory could not interpret. Tartaric acid, for example, exists in two modifications, differing in crystalline form and in their action upon polarized light. One acid was dextrorotatory, the other lævorotatory, while a mixture of the two in equal proportions was neutral to the polarized beam, and gave no rotation at all. Their crystals exhibited a similar difference in the arrangement of certain planes, one set being right-handed; and each crystal resembled its isomer like a reflection in a mirror, alike, but reversed. For a long time this physical isomerism, as it was called, remained inexplicable, for the rules of valency gave to both molecules the same structure and offered no hint as to the cause of the difference. Structural formulæ, however, said nothing of the arrangement of the atoms in tridimensional space, and it was soon suspected that the root of the difficulty was here. The mere linking of the atoms with one another could be represented in a single plane, but that was obviously an imperfect symbolism.

In 1874 Van't Hoff and Le Bel, working independently of each other, suggested a solution of the problem. One simple assumption was enough; merely that the quadrivalent carbon atom was essentially a tetrahedron, or, more precisely, that its four units of chemical attraction were exerted, from a common center, in the direction of four tetrahedral angles. Atoms of that kind could be built up into structures in which right-handedness and left-handedness of arrangement appeared, provided only that each one was united with four other atoms or groups all different in nature. Stereo-chemistry was born, the anomalies vanished, and many new substances showing optical and crystalline properties analogous to those of tartaric acid were soon prepared. The theory of Van't Hoff and Le Bel was fertile, and therefore it was justified; it interpreted another set of phenomena, but, in order to do so, something like atomic form had first to be assumed. It was only a new extension of Dalton's atomic theory, but it has suggested a future development of extraordinary significance. If we can determine, not merely the linking of the atoms, but also their arrangement in space, we should be able, sooner or later, to establish a connection between chemical composition and crystalline form. The architecture of the molecule and the architecture of the crystal must surely, in some way, be related. But the problem is exceedingly complex, and we may have to wait many years before we reach its solution. The atomic theory still has room to grow.

(To be continued.)

SINGLE-PHASE MOTORS FOR ELECTRIC RAILWAYS.

Last year very great interest was excited by the announcement that the Westinghouse Electric and Manufacturing Company had taken a contract to equip the Baltimore, Washington and Annapolis Railway, which extends from Washington, D. C., for a distance of 31 miles to Baltimore, with a branch from Annapolis Junction to Annapolis (15 miles), with an alternate-current system of electric traction.

In the Street Railway Journal there is an article giving the most recent information on this matter. It is stated that alternating current will be supplied to the car at a frequency of 16 2-3 cycles per second, the overhead trolley wire being fed from transformer substations at 1,000 volts. A diagram is given showing the connections and the method of regulation. Commenting upon the subject, the London Magazine finds the description of the motor, the explanation of its construction, provokingly vague. "We are told," continues the latter paper, "that the fundamental difficulty in the operation of the commutator type of motor on single-phase alternating current lines is the sparking at the brushes. This difficulty has been overcome in the present instance by so constructing the motor that the secondary or short circuit current in the armature coil is small, and the commutating conditions so nearly perfect that the combined working and secondary currents can be commutated without sparking; this condition being obtained, the motor operates like a direct-current machine, and gives no trouble at the commutator." This description points to the fact that there have been no radical alterations in the design of the motor, and that the changes have been entirely in the direction of very short coils and low magnetic induction.

Since the time that any serious attempt was made to use series-wound motors with alternate currents, there has been the greatest improvement in the matter of commutation; and it is possible that many of the difficulties which one naturally attributes to alternate-current working belong to a period which has passed, and that the modern machine really does not require so much modification to adapt it for alternate currents as one is at first apt to assume. We learn that there has been an extended series of tests made with the new motors at the Westinghouse shops at East Pittsburg, both in the testing-room and under a car, and that the efficiency curve is practically a straight line from 60 up to 120 horse power, varying from 88 per cent to 89 per cent. The power factor is about 86 per cent, while the torque runs up very nearly in a straight line from 250 pounds, at 1-foot radius, at 58 horse power, to 1,280 pounds, at the same radius, at 122 horse power. There will be four motors of 100 horse power on each car, the full rated voltage of each motor being approximately 200 volts. These will be arranged in two pairs, each consisting of two armatures in series and two fields in series, the two pairs being permanently connected in parallel. Voltage control will be used, and there will be no necessity for series parallel operation. Further, there will be very little energy wasted in rheostats, for by means of an auto-transformer, a second circuit, having approximately 300 volts, can be made either to add to or subtract from the main transformer voltage, thus raising or lowering the voltage supply to the motors. In this way the regulator will be relatively small, as it deals only with the variable element of the voltage, and the maximum voltage in the secondary winding is but half of the total variation required. A generating station for the line is now under construction, and it is to be expected that within a moderate period this most interesting installation will be put in operation.

CONTEMPORARY ELECTRICAL SCIENCE.*

Resistivity of Mercury Vapor.—R. J. Strutt has made a very interesting attempt to bridge the enormous gulf separating the resistance of mercury from that of mercury vapor, which is 4×10^{14} times that of the liquid metal. He argued that this enormous increase in resistivity on vaporization must show some kind of continuity at the critical temperature, when the other physical properties of the liquid and the saturated vapor become indistinguishable. The critical temperature of mercury is unknown. To judge from its surface tension it should be about 750 deg., while its boiling point indicates about 724 deg. On the other hand, Thorpe and Rücker's expansion formula would give a critical temperature of 2,700 deg. The author determined to observe mercury in the critical state by heating it in a quartz cylinder under pressure, but the strongest tube burst at a dull yellow heat, at which the mercury was still distinguishable as liquid and vapor. In arsenic also the critical temperature was found to lie above the dull yellow heat. Up to a full red heat the conductivity of saturated mercury vapor remains of quite a different order of magnitude from that of the liquid, the latter being 10 million times as great as the former. But, on the other hand, the conductivity of the saturated vapor is immensely greater than that of the vapor at atmospheric pressure. The ratio of the densities of the vapor is of quite a different order. It seems likely that as the critical temperature is approached the vapor begins to conduct freely, while the liquid changes its electrical character to a much less extent. The conductivity of saturated arsenic vapor at a bright red heat is of the same order as that of mercury, and obeys Ohm's law, at all events up to an electromotive intensity of more than 100 volts per centimeter. The author does not believe that the critical phenomena of metals will ever be observed, but recommends a careful study of the resistance of hot mercury.—Hon. R. J. Strutt, Phil. Mag., November, 1902.

Magnetic Detector.—C. Tissot describes a magnetic detector somewhat like Marconi's instrument, but employed not for long-distance telegraphy, but for the exact measurement of the effects at distances of 2 or 3 miles. He used it in conjunction with a bolometer capable of measuring the thermal energy received by the antenna. He was thus enabled to study the nature of the detector action, and found that it is not a magnetic lag which is affected by the electromagnetic wave, but that it is hysteresis proper. The effect is sensibly independent of the rate at which the field varies, and is much better in the case of steel than of soft iron. The cores giving the best effect are those consisting of a material whose cycle of magnetization embraces a large surface. The author has constructed two detectors which have a sensitiveness equal to that of the coherer. In one of them the core is fixed and finely laminated, and bears 50 or 60 turns of fine wire. A small coil of several hundred turns of the same wire is placed at the center of the first turn and joined to the telephone. The variable field is produced by the rotation of a magnet. In another form, which recalls a Gramme ring, rotational hysteresis is brought into play. The distances covered are 25 to 30 miles.—C. Tissot, Comptes Rendus, February 9, 1903.

Inductive Magnetic Resistance.—J. Zenneck claims that in a number of phenomena of electromagnetic oscillation the conception of inductive magnetic resistance or "magnetic inductance" may be of service if the phenomena are to be treated in an elementary and purely qualitative manner, more especially for orientation among the phenomena of commercial alternating currents. Closed coils, metallic tubes, rods or disks behave in an alternating magnetic field in the direction of their axes in a manner as if their magnetic resistance had been increased. This apparent increase of magnetic resistance, in the case, at least, of short-circuited coils and metallic tubes consists in the addition of an inductive magnetic resistance to the "ohmic" magnetic resistance as determined from the dimensions and the permeability. In solid rods and disks, however, the "ohmic" magnetic resistance itself experiences an increase. The amount of the total ohmic and inductive resistance can in simple cases be calculated from the geometrical dimensions, the conductivity and the permeability. As soon as it is calculated, it is as easy to operate with it as, say, with the impedance of a choking coil. Most of the calculations can be made graphically with the aid of vector diagrams.—J. Zenneck, Ann. der Physik, No. 11, 1902.

Selenium.—J. W. Giltay describes some improvements in his lecture apparatus for exhibiting the sensitiveness of selenium to light. He substitutes a glass plate with six windows, for the ebonite plate with eight windows for intermittent illumination, and makes the dark intervals somewhat longer than the light ones on account of the lag in the light effect. Another species of intermittent illumination is produced by mounting a radiometer in the path of the beam. The author employs one with eight vanes, and obtains a good effect in the telephone. The illumination may also be made intermittent by means of a manometric flame. The best for the purpose is an acetylene flame, but, in order to increase the effect, the author uses three such flames side by side, worked by the same

* Compiled by E. E. Fournier d'Albe in the Electrician.

membrane. It is then possible to make the distance between the selenium cell and the flame as much as 10 cm., and thus save the former from injury by heat. The author finally warns against an effect he has observed when the circuit containing the selenium cell, battery, and telephone is broken. The extra current then induced often short-circuits the selenium cell, and to avoid this he shunts the cell by means of a commutator in which he inserts a plug before breaking the circuit.—J. W. Giltay, Physikal. Zeitschr., February 15, 1903.

THE AGAVES—A REMARKABLE GROUP OF USEFUL PLANTS.*

By E. W. NELSON, Field Naturalist, Biological Survey.

THE early explorations in America brought to the attention of Europeans various novel forms of plant life which were utilized by the Indians for food or in their primitive industries. Some of these plants were found in the wilderness, where the natives searched for their products at the proper season; others had become of such importance and value that they were cultivated in a crude way over large areas. The European colonists, recognizing their utility, developed several of these plants, the most notable of which, for the part it has played in the early settlement and subsequent growth of America, is Indian corn.

Among the many strange and interesting plants found in the Mexican wonderland by Cortez and his followers were those forming the group variously known to-day as Century-plants, Agaves, or Magueys, one of the most remarkable groups of the plant world. Humboldt considered the Agaves, next to maize and potatoes, the most useful of the natural products of tropical America. They are placed by botanists in the genus *Agave* of the Amaryllidaceæ, a family closely related to the lilies.

The Agaves are natives of America, where they occur from southern Nevada, Utah, and Texas, south through Mexico and Central America into Brazil. Their strongly individualized and picturesque character renders them especially interesting for decorative purposes, and the early botanical travelers, sent to gather strange plants for European commercial gardens, brought home numerous species for propagation, which were distributed to various parts of Europe. Many of these were new to science, and attracted the attention of botanists, who gave them names, but were usually unable to state definitely the place of origin of the species described. Others have been described from herbarium specimens, often with an equal lack of information as to the region whence they came. The result is a multitude of named species with but little definite information of the distribution of more than a very few. Dr. J. N. Rose, probably the best American authority on these plants, estimates that there are about 150 recognizable species now known in the genus *Agave*, although botanists have bestowed upon them more than twice that number of names. From present knowledge of the group, however, it is safe to predict that future study will demonstrate the existence of many more species. Agaves are most numerous, both in species and individuals, in the arid and semiarid parts of the table-land of Mexico and adjacent mountain slopes. Their center of abundance is in the Austral life zones between the altitudes of 2,000 and 8,000 feet; still some species thrive on the low coastal plains of the Tropics, and others on the rugged crests of desert mountains in the Transition zone, from 8,000 to 10,000 feet above the sea. During the summer of 1902 the writer found a sturdy species similar to *Agave wislizeni* in rocky places among the firs and pines at an altitude of 10,000 feet in the State of Coahuila, Mexico.

The geological formation has a direct influence on the growth and abundance of Agaves. Limestone areas, where the bed rock is exposed in many places, and has only a thin cap of soil when covered, appears to be most favorable to their development. In Mexico and the southwestern United States are vast limestone areas, especially in Yucatan and the plains and mountains of the northeastern part of the Mexican table-land and western Texas. In many parts of these areas various species of Agave often grow in such thorny abundance that it is difficult to pick one's way among them. Mr. Vernon Bailey has estimated that about 20,000 square miles of limestone territory in western Texas is covered more or less abundantly with the small *Agave lecheguilla*.

Second in importance to limestone in its influence on the growth and distribution of Agaves are volcanic formations such as are seen about the southern end of the Mexican table-land.

All Agaves require years for their development before flowering, and this has given rise to the popular name "Century-plant," borne by *Agave americana*; it is doubtful if any species under natural conditions actually spends more than fifteen or twenty years in maturing.

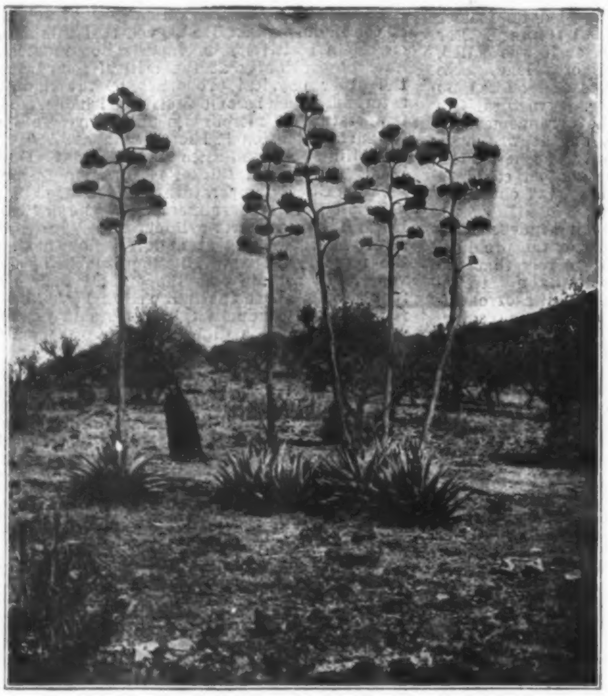


FIG. 1.—GROUP OF AGAVE WISLIZENI, WESTERN TEXAS.

FIG. 2.—PULQUE GATHERER, VALLEY OF MEXICO.

The Century-plant (*Agave americana*) may be taken as a typical member of the genus, though there are numerous modifications of this type among the many known species. Practically all agree in having more or less rigid leaves, each broadly attached at the base and terminating in a strong, horny spine. The leaves vary greatly. In some species they are long and slender, with smooth edges; in others long and fleshy, with heavy, recurved claw-like spines set at short intervals along their borders; and in others, short, broad, and still more formidably armed with spines. These armed leaves, clustered about the base of the plant, bristle threateningly at all comers, and serve forcefully to protect the tender tips of the budding flower stalks that might otherwise furnish tidbits to hungry rabbits and ruminants. The puncture made by the stout spine at the end of the leaf is very painful. When, in addition to this terminal spine, the leaves of a large plant have their sides thickly set with strong, claw-like thorns the protection they afford becomes very evident to the plant collector who tries to reach the flower stem without first cutting away the outer leaves.

FIG. 3.—HEDGES OF PULQUE, MAGUEY, VALLEY OF MEXICO.

* From Yearbook of Department of Agriculture.

PRINCIPAL TYPES OF AGAVES.

There are four principal types of development among these plants: (1) *Agave wislizeni* (Fig. 1), with short, broad leaves, found in the mountains of western Texas; (2) the tequila plant of Jalisco, with large, fleshy base bearing numerous long, slender leaves; (3) the Sisal Agave of Yucatan, with yucca-like trunk; and, (4) a form found on the Mexican table-land, characterized by the development of large, fleshy leaves on a comparatively small base.

The most striking member of the last-mentioned

FIG. 4.—TEQUILA PLANTATION, JALISCO, MEXICO.

FIG. 5.—MULE TRAIN CARRYING BASES OF TEQUILA AGAVE TO DISTILLERY, JALISCO, MEXICO.

type is the huge Pulque Maguey, the giant of the entire group, which thrives best between 6,000 and 8,000 feet above sea level on the semiarid plains of the southern half of the Mexican table-land. It reaches its greatest development in Toluca Valley and the valley of Mexico, where the huge, fleshy leaves are sometimes 9 feet long and weigh over 100 pounds each, though usually much smaller. Every plant bears from 25 to 50 leaves around a massive, fleshy base, and the largest plants weigh from 1 to 2 tons each.

The Pulque Maguey.

Pulque, the national drink of the Mexicans, is made from the juice or sap of the Pulque Maguey. The valley of Mexico is the center of cultivation of this plant, and many extensive haciendas or plantations that are devoted entirely to growing it yield large revenues to their owners. The plants when two or three years old are set out in long, parallel rows; they reach maturity in from twelve to fourteen years. In order to insure a succession of harvests, new settings are planted yearly, and even with the long delay in the first crop the business is very profitable. The large, fleshy leaves, as in other members of this genus, are persistent, and spend all the years of their immaturity in slowly storing up quantities of sweet sap. At the expiration of this long period, which might almost be called a period of incubation, a change occurs in the plant's organism. It has attained the supreme moment toward which all the hoarding of sap during the past years has been directed; the character of its activity changes, and with marvelous rapidity a gigantic central flower stalk shoots up 20 to 50 feet. This stalk, which is sometimes a foot in diameter at the base, is fed generously from the store of sap in the base and leaves. Its upper end branches like a candelabrum, and greenish-white flowers spring forth in palmated clusters. Humming-birds, orioles, and various insects, attracted by the nectar of the blossoms, pass from plant to plant, and thus insure fertilization, the object of the plant's existence. After the seeds form, the leaves and base, having exhausted themselves in this final effort, wither and die.

FIG. 6.—CUTTING LEAVES OF SISAL AGAVE IN YUCATAN, MEXICO.

FIG. 7.—DRYING SISAL FIBER AT STRIPPING MILL, NEAR MERIDA, YUCATAN, MEXICO.

On the pulque plantations the plant is not permitted to run its natural course, but is subjected to special treatment. Fig. 2 shows the process of collecting and transporting the juice of the pulque by gatherers, who every day or two for several months visit the tapped plants.

The value of the total product of pulque amounts to millions of dollars annually.

The Pulque Maguey is also commonly set out as a hedge about fields and gardens and its sap gathered for family consumption. This mode of cultivation is shown in Fig. 3.

The Mescal.

In addition to the species of Agave that yield pulque, a number are utilized to produce distilled alcoholic liquors of different kinds. An alcoholic drink common in Mexico, the product of the Agave, is known as "mescal."

Other liquors distilled from various species of the Mescal Agave are known as "tequila," "huila" and "comiteco." Figs. 4 and 5 show a tequila plantation and the manner of transporting the bases of the plant.

USE OF AGAVES AS FOOD.

So far in the story of these plants there has been room for question as to their ultimate benefit to mankind. There is no doubt, however, concerning the usefulness of certain other members of the genus. The fleshy bases of numerous species of Agave are roasted and eaten by Indians and mountaineers both in Mexico and the southwestern United States. Several of the six species growing wild in southern Nevada, Arizona, New Mexico, and Texas have been well known to the Indian tribes of that region from time immemorial, and still retain the Mexican name "Mescal," whence was derived the name of the Mescalero Apaches of southern New Mexico. The fleshy bases of the Mescal are prepared for food in practically the same manner both in Mexico and the United States. Mescal "pits" are made by heaping up masses of Agave bases with fuel and covering them with stones and earth, much in the form of charcoal pits, after which the mass is fired. The slow roasting which results lasts from one to three days and brings about certain changes. The fleshy substance becomes sweet, and the heart of the plant tender, with much the taste and consistency of an artichoke. Sometimes a shallow pit is dug and lined with stones, which are thoroughly heated by building a fire on top of them. The bases of the Agaves are then freed from their leaves and placed on the stones; a fire is built over them, which, when well started, is covered with earth, and they are left to roast. Roasted mescal is still commonly sold in the market places of small towns over a large part of Mexico and to some extent among Mexicans in towns along the southwestern border of the United States.

MISCELLANEOUS USES OF AGAVES.

The juice of the young leaves of some species is acrid and a mild irritant, and the fresh pulp applied to the skin produces an irritation similar to that of a weak mustard plaster. In ancient times the fresh juice was used to cauterize and cleanse wounds.

The strong terminal thorns of some species were used by the Aztec priests to pierce their tongues, ears, and other parts during certain rites of expiation. The slender flower stalks formerly served for lance shafts, and the large ones are still used by the natives as rafters for their small houses and for fences. The large hollowed leaves are frequently employed to thatch the huts of the poor, both in the country and about the borders of towns.

A number of species of Agaves, known as "Amoles," contain such an abundant supply of saponin that the fleshy parts of the leaves, bases, and sometimes of the roots when rubbed up in water make a good lather and serve excellently for soap. This substance is a satisfactory emollient to the skin, and the Mexican women prize it for washing their hair, which it makes both soft and glossy. It has already entered into the composition of a manufactured hair wash, and efforts have been made to make a soap from it. It is free from alkali, removes stains from delicate fabrics, is said to set colors, and does not shrink flannels like ordinary soap. In southern Arizona *Agave schotti* is the main soap-yielding species, and its properties are well known to the Mexicans of the region, who also call it "Amole."

The Aztecs also utilized the Agave leaves for making a tough paper, upon long, narrow sheets of which were painted in brilliant colors their pictured historical records. Some of these records, known as codices, still exist in collections, and both the colors and paper appear to be little affected by the lapse of the centuries since they were made. The paper of the Aztecs is of a dingy color, but in 1854 a company in Mexico succeeded in making from the Agave leaves a great variety of papers, from the coarsest cardboard to the finest white letter paper, all characterized by unusual toughness and durability, some grades almost equaling parchment in this respect.

TEXTILE PRODUCTS FROM AGAVES.

All Agaves have series of long, slender fibers extending in a thin longitudinal layer just under the surface of each leaf, and centering in the strong horny spine at the tip. The writer has at various times seen the natives, when wishing to hastily repair a coarse garment or sacking, break loose this thorny

point of an Agave leaf, and, stripping it away with some of the attached fibers, thus provide themselves with a stout, ready-made needle all threaded for use. The length, strength, quantity, and quality of this fiber vary greatly in different species. The length of the fiber in each case is governed by the length of the leaf. The fibers of the Pulque Maguey are small in quantity and not very strong, but are very long, soft, and silky in texture. They were woven by the Aztecs into soft, delicate garments for the nobles. These garments were often brilliantly colored with native dyes and handsomely embroidered, and their fineness and beauty excited the admiration of the early Spanish invaders.

The uses of Agave fiber among the Mexicans have come down as an inheritance from prehistoric times. Each community knows perfectly the quality of fiber yielded by every kind of Agave growing in its district, and the ranchmen and villagers gather from the wild plants on the surrounding hills the material for their cords, ropes, sacking, and a variety of other articles. The articles made in excess of local demand are taken to market in the larger villages, and form one of the regular but small sources of income to the natives. In some districts, where the wild Agaves yield a specially good quality of fiber, the outside demand for the product has created local industries of some importance. Usually products of this kind are in the hands of scattered individuals, mainly Indians, who work in the crudest manner, but in many places the industry has a larger growth under direction of the owners of haciendas, who thus add materially to the revenues of their possessions.

The best fiber-producing Agaves grow in districts where the geological formation is wholly limestone, and often on areas where the underlying rock is covered with barely enough soil to give the plants foothold. The only two districts in Mexico where Agaves are cultivated extensively for their fiber—Tamaulipas and Yucatan—are of this character, the underlying limestone outcropping at short intervals and at best only thinly covered with soil. The first of these areas is situated at an altitude of between 1,500 and 5,000 feet above sea level in western Tamaulipas, and covers the valleys of Jaumave and Tula. It annually exports through the port of Tampico to the United States nearly $500,000 worth of the fiber, which is obtained partly from a wild Agave (*Agave heteracantha*) growing on the sloping borders of the valley and partly from a similar plant cultivated in the valley bottoms, which reaches a much larger size. The fiber from this district is called "ixtle," and is packed on mules to the nearest railroad point for shipment to the coast.

Yucatan is the main center of production for Agave fibers in Mexico. The peninsula of Yucatan is a limestone plain but little above sea level and with a thin covering of soil. On this thrives *Agave sisalana*, the plant which yields the "sisal," "sisal hemp," or "henequin" of commerce. This is cultivated on large plantations, which, under present conditions, are enormously profitable to their owners. Fig. 6 shows the Indian workmen cutting the fiber-bearing leaves of the sisal on a plantation near Merida, the capital of Yucatan. Yucatan now exports annually about $12,000,000 worth of this fiber to this country, and the amount is steadily increasing. The climate of the peninsula in the sisal district is arid tropical, and the country, though its extremely rocky character renders it almost worthless for any other crop, from this source alone is rapidly becoming, in proportion to its population, one of the richest sections of Mexico. Some ingenious machinery has been invented for stripping the fleshy pulp from the fiber of the leaves. Fig. 7 shows the freshly cleaned fiber lying on drying frames at one of the stripping mills on a plantation near the city of Merida.

The success of the cultivation of the Yucatan Agave has led to its introduction into the Bahamas and some of the West Indian islands. Over sixty years ago it was introduced into southern Florida by Dr. Perrine, American consul at Campeche, who tried to acclimatize useful tropical plants in this extreme southern part of the United States. More recently it is reported that efforts are being made to introduce it into the State of Tamaulipas, Mexico. Yucatan lies below the frost line, and it is a question whether the Agave of that region will prove hardy enough to grow within a frost-visited area. But the "lecheguilla," as the Agave that produces the ixtle fiber of western Tamaulipas is called (probably a distinct species from the *Agave lecheguilla* of Texas), is hardy enough to withstand sharp frosts, and thrives naturally on land practically worthless for other purposes. It is quite possible that it might be profitably grown on land not otherwise available for agriculture in the large area in western Texas where the *Agave lecheguilla* is found, or in other sections of some of the southwestern border States. It may be that the native plant, the *Agave lecheguilla*, which has a shorter, coarser fiber of unknown value, would repay exploitation. The enormous increase during recent years in the value of the Mexican fiber product from this source, with its main market in the United States, appears to justify experiments in the introduction of some of the species of demonstrated value.

CONCLUSION.

By way of conclusion of this brief account of the Agaves, it may be stated that their varied employment for food, drink, soap, clothing, cordage, needles and thread, paper, parts of dwellings, parts of weapons, sacrificial implements, medicaments, and ornamental garden plants amply justifies Humboldt's estimate of their usefulness to mankind.

Lightning Spot Remover.—This lightning cleansing agent is composed of strong ammonia solution 31 parts, potash-soap tincture 93 parts, soda 7.8 parts, borax 7.8 parts, ether 31 parts, spirit of wine 31 parts, and enough water to make up a total of 950 parts.

In preparing the liquid, it is necessary to dissolve the salts in one part of the water, then to add the remaining substance, and finally the ether and alcohol.

This preparation, it is claimed, will remove spots from all woolen fabrics, render black cloth glossy, clean carpets, etc.—Drogisten Zeitung.

INSECT PESTS OF PLANTS AND THEIR EFFECT ON AMERICAN AGRICULTURE.*

By Prof. F. M. Webster.

I wish to approach this subject, assigned to me by your president, by calling your attention to the fact that without agriculture there would be no such pests. That is to say, destructive insects were never created as such, and they become pests only when they come in contact with the ever-widening and varying interests of the husbandman. A weed is but a plant out of place, and an insect may be either beneficial or innoxious to-day and a most destructive pest to-morrow, precisely as the plant upon which it feeds comes to possess a financial value. The dusky aborigine, whose cultivated fields were few and far between, had little difficulty with insect pests, and this was true in case of the white pioneer, because there was food for man and insect in plenty and this fight for life between man and the most diminutive of the lower animals had as yet scarcely begun. The red man and the bison have succumbed to the Caucasian and are practically exterminated, because of their inability to adapt themselves to the changed conditions prevailing through the influence of civilization. Insects do not give way to the white man so easily; the minor here becomes the major, and they adapt themselves to changed conditions as to food plants, prey upon the crops of the farmer and thereby become insect pests. Therefore, like the poor, they have been always with us, and always will be. The whole problem is summed up in the efforts of natural selection to keep pace with artificial selection.

Besides being tenacious, as I have just shown, insects differ from man and the larger animals in many other ways, and we find that what in many cases appears the weaker is by far the stronger. Man and many of the larger animals mature slowly, their progeny are few in number and produce at more or less protracted intervals. An insect born to-day may itself produce young within a week, not singly but in myriads. It might almost be said that animals reproduce in numbers and frequency inversely to the amount of their avoirdupois, the most gigantic producing but a single young at long intervals, while the offspring of a single insect mother may number thousands, and some of them go through their entire life cycle within the space of a few days.

Again, as we sit here beside one of the world's greatest natural wonders, with our own starry banner floating grandly in the breeze, the soldiery about it coated in blue, we look across the narrow and restless thread of water and behold another equally proud banner, this one largely of red embellished with the cross of St. George, and the soldiery is there coated in red. We have but to cross the short steel path that spans the swift river and we are in another country, with different laws and political regulations, with different rules. Now, if we cross back and forth between these we are stopped, questioned, and perhaps searched by officers of either one of these nations, but the little honey bee wings her flight back and forth from the clover fields on either side of her hive, and lands her cargo duty free, and all the power of King Edward and President Roosevelt combined cannot prevent her doing so. We have but to go to the banks of the Rio Grande far to the south to witness a parallel to these same conditions. I have used the honey bee as an illustration of my point, but later on I shall show you that there are many other and destructive insects that proceed in much the same manner, bidding defiance to the laws of nations as well as states and territories. One of the worst scourges of the cotton field made its way across the lower Rio Grande from Mexico, a few years ago, and is now spreading its blighting hordes over the cotton-growing regions of the South with a final result of we know not what to this most important industry. It is no uncommon thing for an insect introduced into this country from abroad to radically change its habits on becoming established among us, and thus not only survive but become decidedly destructive as well. What has come to be known as the Buffalo Carpet Beetle, introduced into the Atlantic States from Germany, into California from Asia, and which has created almost a panic among American housewives in the East, in California, and in Europe, is unknown as a household pest, living there in the blossoms of plants. Thus we find that insects are exceedingly prolific organisms, cosmopolitan, seemingly capable of adapting themselves with ease to almost any climatic changes or variations in the nature of their food supply. Their fossil remains preserved in the rocks teach us that while man and the larger animals come and go, they live on—we might almost suspect—forever. Let us now see what they cost the American farmer and whether or not they are of sufficient importance for him to consider, as a factor in his business.

In the past, on every $1,000 worth of farm produce marketed by the American farmer, a tribute of over $100 or over 10 per cent has been paid to the great army of destructive insects. In other words, it costs the agriculturists of America over $300 000,000 annually to support this devastating horde of destructive insects, and the figures given are based on very conservative estimates. The last national Congress appropriated for the use of the United States army and naval service combined the sum of $170,586,499.54, only a little over half the above amount, and the farmer shook his head over the magnitude of his expenditures. In 1900, the latest statistics to which I have access show that the entire expenditure for public education in the United States was $213,274,354. For the year 1900-1901 the government and municipal appropriations for universities and colleges of liberal arts in the United States was $5,052,392, the total income of these during the same year being $22,789,054. From these figures we can see that it costs us more to keep these insects than it does to educate our children, and the loss does not fall upon the whole population but upon those whose interests are in agricultural pursuits. It is the farmer who pays this tribute of one dollar of every ten for the support of the insects, yet few agricultural colleges require the study of insects at all—enemies of his crops. The loss by fire in the United States during the year 1902 was estimated at $140,000,000, the average annual loss since 1874 being $114,066,953, and again we find that loss through insect attack is more than twice that by fire. We have fire insurance companies galore, but who ever heard of an insect insurance company? A $10,000 fire in one part of the country is heralded from one side of the continent to the other and more stir occasioned than does the attacks of the cotton boll weevil in Texas, whose ravages the present year will probably amount to upward of $20,000,000. The chinch bug may work a $20,000,000 damage in the timothy meadows of New York or in the wheat and corn fields of the Middle West, and attract less attention than a $20,000 fire in Chicago or New York city. From the best information that I am able to obtain, this chinch bug between the years 1850 and 1898, caused a loss of $330,000,000. If fire losses were as great as losses by insects, insurance companies as at present organized would have to close up business. These are losses the magnitude of which can be approximately estimated because the effects are not as obscure as in many instances of insect attack. There are insects whose methods of attack are so obscure and covert that they are not usually discovered at all by the ordinary farmer, who simply knows at the end of the year that his crops have not done well and the year has been an unprofitable one for him. Perhaps some of the wheat straw worms have attacked his wheat, and the result has only shown in the shriveled condition and light weight of the kernels, with no apparent connection between the two. His corn has not grown well, the ears are short and not well filled out at the tips, precisely as if his land was lacking in fertility or a drouth had prevailed, and he may lay the loss to either the weather or his land, whereas it was the corn root worm that ruined his crop, a pest that he might easily have avoided. His timothy meadow has died out and he does not know why it should have done so, when had he looked carefully about the roots he would have found the short-winged form of the chinch bug present there in myriads. Such losses as these are not considered at all by the farmer or statistician, unless they are of such magnitude as to devastate large areas of country, and the figures that I have given, though they may appear large, are more likely to be under than over drawn. Here we have a financial loss, falling upon a single industry, nearly three times as great as that caused by fire, and to ask if such a factor should be reckoned upon and carefully considered by those engaged in that industry appears almost ridiculous, as it would seem to go without saying that such elements should not only receive most careful consideration, but every effort should be made by those engaged in that industry to familiarize themselves with the minutest details thereof in order to by every possible means protect themselves against its adverse influences. In no other business under the sun would such an important element escape most careful and thorough consideration, and every person engaged in that industry or business would be as familiar with the details thereof as possible. Judging from my own quite extensive acquaintance among the farmers of the Middle West, having spent my whole life among them, and over twenty years as an entomologist, working upon the problems indicated so clearly by the title of my paper, I do not believe that more than one farmer in a thousand has any conception of the nature of the insect enemies of his crops that are permanent residents of his premises, and liable at any time to occur in sufficient abundance to cause him a greater or lesser financial loss. One of my own tenants is a good farmer, as the term is applied among farmers. I have had him with me eighteen years, but in all that time he has not learned to recognize a single insect in its different stages. He knows the cut worm when he finds it at work in his corn field, as also the wire worm when observed under the same conditions, but he does not know a thing of these in their adult stage. If I talk to him about the insects of the farm, he listens respectfully for a while, may ask a question or two, but again, more out of respect than anything else, finally steers the conversation into the cost of fattening the last carload of cattle or hogs, repairs to the barn, a new variety of oats, anything else except insects, which he cannot understand as being of any special interest to him. Now, I have got a good farmer, and I believe his interest in applied entomology is on a par with that of most of the tillers of the soil generally over the country. From my acquaintance with them, gained by months of residence among them, on their plantations, I believe the Southern planter is better posted in this direction than the Northern farmer. The planter is not always in so much of a perpetual hurry, has more leisure to read and think, and his neighbors of equal social standing being more widely scattered, when he meets them are more inclined to discuss such matters together, and thus exchange opinions and experiences. In other words, he perhaps reads less but digests better; and if he had the same grade of labor that exists in the North, so that he could get his wishes intelligently put into effect, the problem of insect control would come nearer a solution, in many cases, than is now being done on the Northern farms.

Again, I do not believe that men engaged in other lines of business and also in farming, pay as much attention to the insect problem as they would if it were another element entering into some of their other interests. I will explain my position by illustration. Some years ago, a banker called me up by telephone and asked me to meet him at his office in order that he might consult me relative to serious trouble in his growing corn, of which he had about 10,000 acres in an adjoining county. I found him very much concerned over what had appeared to him as an entirely new trouble that was likely to cost him a small fortune, his crop being damaged in some fields from 25 to 75 per cent. He was sure that it was an entirely new pest, as he had never heard or read of anything of the sort. It did not take long to give me sufficient details to show conclusively that it was the corn-root worm that was ravaging his fields, and, as he stated, costing him at least $10,000 per year. It

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* Read before the 23d annual session of the Farmers' National Congress at Niagara Falls, N. Y., September, 1903.

was pointed out to him that the pest was not a new one, but on the contrary had been known as a serious enemy of corn for many years, and that the remedy, a rotation of crop, was entirely within his ability to carry out. Besides, it was shown him that full descriptions of the insect, its method of attack, and importance to the corn grower had all been published over and over again. Surely, if his receiving teller at the bank had accepted a very limited number of counterfeit $50 bills, the matter would have received prompt and decisive attention, and further loss prevented, but the $10,000 per year insect leak had been going on for he knew not how long.

Another time, a manufacturer of grain harvesters and also a large land owner, took me to some of his fields, and was shown it was this very same pest of the corn field that was committing very serious depredations; clear enough to him after they were pointed out to him. He was advised of the one practical and thoroughly efficient preventive measure, that of a simple rotation of crop, and appeared to thoroughly understand the nature of the pest with which he was dealing and the measures to be applied in exterminating it. Being also somewhat eccentric, he appeared to rather overestimate my own connection with the matter, but faithfully carried out my recommendation. As I afterward learned, he rotated his corn land of that year with a crop of oats the following season, exterminating the corn-root worm; but the army worm came that year and destroyed the oat crop, a combination of circumstances that neither I nor anyone else could foresee. A year later, and after I had almost forgotten the matter, while walking along the street of a neighboring city, I suddenly felt myself in the hands of some one whose grip and weight with which it fell on my shoulder might have been a policeman from Chicago, but who proved to be my manufacturer friend. With a number of descriptive adjectives, by no means of an entomological character, he informed me that I was an ass, and that the corn insect that I said would be exterminated by a rotation of crop, instead of being exterminated had changed to something else—had actually become more destructive and ruined his oats—and he thought the whole lot of blankety-blank entomologists ought to be exterminated instead of the insects. Keen as he was in his business as a manufacturer, as a farmer he had totally neglected to familiarize himself with the insect factor, which was costing him so much money, and did not know that the insect attacking the corn and the one attacking the oats had no relation to each other and that their occurrence in his field, following each other as they did, was simply a coincidence, and that he had accomplished all that he had set out to do under my direction. It is safe to say that nothing of this sort ever did or ever would occur in his shops where factors of vastly less importance were considered and promptly acted upon with an intelligence to be gained only by the mastery of minute details. I give these illustrations to show that there is a sort of indifference toward insects and their ravages that does not appear in businesses other than agricultural pursuits but, nevertheless, seems to be a sort of constitutional defect of the human race. This may be due to their minute size and the fact that being insects and always with us, we become so used to them and their effects that we accept them as less civilized people do, as we do the winds and storms, heat and cold—elements that must be accepted as they occur and nothing done to control them. I have thus gone over these matters in some detail, in order to show the conditions under which the agriculturist labors, as relating both to insects and that which I might almost term superstitions relating to them and their ravages. Indeed, as one of my fellow entomologists has pointed out, well informed men who put enormous stress on the fact that by certain processes they can save one-tenth of one per cent in the butter fat in their milk, seem utterly unable to realize a loss of 10, 15 or 50 per cent in the productive capacity of their pastures, meadows, and grain fields as long as there is no total devastation. After we have worked out the life history of an insect, found the vulnerable point, so to speak, in its methods of living and reproducing, found remedial and preventive measures that are effective and the application of which are entirely practicable, we still have to deal with the equally uncertain element of man's apparent apathy regarding insects, whether good or bad, and their relation to his financial interests. Those who are inclined to consider and act in such matters are frequently discouraged and hampered by those about them, and whose inaction will be sure to more or less counteract their efforts to control these insidious pests, and any measure of protection will be more or less defeated in its effect if it does not ward off attack from adjoining premises as well as destroy. An orchardist may spray his trees and kill every codling moth larva that hatches on his own premises before any damage is done, only to learn later on in the season that his neighbor has raised enough of the second brood of moths to invade his orchard and destroy his fruit after he has himself protected it until the crop seems almost assured. A good spraying machine is a most valuable article on any farm, but if one were to start out to sell a really good article, he will be astounded at the number of farmers and fruit growers who have no use for them. It may not be out of place just here to call attention to the fact that the manufacturers of the one-dollar trap lantern, a worse than useless invention, made a fortune out of the sale of them in spite of all warning.

I have discussed these phases of the problem at some length in order to show the magnitude, as well as the difficulties with which its solution is surrounded. There never will be a time when we do not have to fight these pests, when eternal vigilance will not be the price of good fruit and profitable grain, grass, cotton, rice, or in fact any other crop. The scientific man may work out scientific problems, the experiment station may demonstrate the practical application of the results obtained, but of what avail is all of this if the husbandman does not himself put his shoulder to the wheel and help himself? If we are ever to reduce this annual tribute of $300,000,000 it is the agriculturist himself that will have to do it. He is on the ground; can see the situation exactly as it is; see hundreds of obscure but significant features of the problem that the man in his office or laboratory cannot observe; can note the inter-relationships between earth and air, between the animal and the vegetable, all as he goes about his fields. He sees Nature at short range, sees her as she is; in fact he is transacting business with Nature every day. He is right out on the firing line and can see things as they are; is in the best possible situation to take advantage of the information furnished him by others. Not only this, but it is his own money that he is saving. Talk of cheapening the cost of production is all right enough, but we seem to lose sight of the fact that it costs almost as much to produce half a crop, as it does a whole one, so far as labor and seed are concerned; and a crop of corn, cotton, hay, or any other that has been injured from 5 to 50 per cent by insect attack will cost the farmer or planter nearly if not quite as much as would a full crop, with no proportionate increase in prices, unless the trouble is of such a nature as to affect a vast area of country, thus preventing the supplying of the deficiency from a distance. We are not in the habit of looking at this $300,000,000 as so much added to the cost of production, and we even hear it said that insect pests are a blessing in that they prevent over-production and low prices, but it seems to me that if the American husbandman could save this, prices would somewhat lower. The loss of two or three million dollars in any one State, by the ravages of the Hessian fly, chinch bug, or cotton-boll weevil, means that there will be that much less money brought into that section of the country to circulate back and forth through the banks as it flows through the various channels of trade. It means less business for the merchant and professional man and less work for the mechanic and day laborer, and if anything, increases the cost of his living. Wheat may be $1 per bushel and cotton $4 per bale, but what will this avail in a community where there is little or none to sell? I mention these things to show the far-reaching effects of losses through the causes that I am discussing. The farmer feeds and clothes the world, and anything that affects the products of his industry affects not only every kind of business, but everybody in any way connected with such business. I have now given you the basis of my discussion of the insect problem as relating to agricultural pursuits.

Our destructive insects have been derived from two sources, viz., native species that have become adapted to the changed conditions brought about by the advancement of civilization, and which may be subdivided into such as, though native to the western hemisphere, have diffused themselves in a perfectly natural manner, more or less aided by the food supply offered by the crops of the agriculturist, and such as seem to be established within our territory until they have become sufficiently specialized to offer little or no indication of their ancient home elsewhere; and such as have been introduced accidentally from other countries.

There are comparatively few destructive insects that have not come to us from other lands, either by natural diffusion or by artificial and accidental introduction. The several species of click beetles, parents of the wire-worms, and the nocturnal moths, parents of the cut-worms, the plum curculio, and a few others were here long before the white men, the two former inhabiting the corn fields of the dusky savage, and the latter breeding in the wild plums of the woods. Of the others which we cannot trace to transoceanic countries, nearly all can be followed to their ancient home in the equatorial regions. The cotton worm is a South American insect, probably having been diffused long ago, possibly largely by the aid of the winds, as the moths are found not only in Central Ohio, but even in Ontario, Canada, occasionally immediately after a southwest gale. The cotton boll worm ranges over England, Central and Southern Europe, Central and Southern Asia, Africa, America, and Australia. The army worm ranges over Madeira, Southern Asia, North America, New Zealand, Australia, and is sometimes found in England. The codling moth is found in England and Ireland, north and west Central Asia, North America, New Zealand, and Australia. The cotton boll weevil has come up from the south and crossed the Rio Grande into Texas within the last few years. The harlequin cabbage bug did precisely the same thing thirty-five or forty years ago, and we can trace the western corn root worm, the chinch bug, the striped cucumber beetle and their allies southward through Mexico into Central America, and there are many others of our destructive insects that have come to us, by what may be termed natural diffusion, influenced so far as we can now determine by climate and an abundance of food. In fact, we come back to the illustration of the honey bee on a much larger scale, as these insects have passed and repassed the borders of nations as well as those of states, with never a hand raised against them.

Again, there are other insects that have been brought to our shores from other countries, and they, too, have found a congenial climate and an ample food supply. These have gained a foothold, largely along the seacoasts, and spread inland, those that have become established on the Atlantic Coast far outnumbering those that have found a home on the Pacific Coast. Some of these have thrived most wonderfully in this country and have become among our most insidious pests. The codling moth, the gypsy moth, the leopard moth, the clothes moth, the oyster-shell bark louse, the Hessian fly, the clover root borer, and the clover leaf weevil, the asparagus beetles, two in number, the cabbage butterfly, the currant worm, the horn fly, the elm leaf beetle, the willow curculio, and a myriad of others that have helped to swell this enormous annual loss to the country, first appeared along our eastern coast line. On the Pacific Coast the scale insects, especially the notorious San Jose scale, the potato tuber moth, and some others, have done their full share in the work of devastation; one alone, the cottony cushion scale of the orange, at one time threatened to wipe out the entire orange growing industry along the west coast, and would probably have done so but for the fortunate introduction of its mortal enemy from Australia that put an end to its ravages. The Cordilleran mountain system forms an almost impassable barrier to the eastward advancement of species introduced along the west coast, and the most of those coming to us from across the Pacific come from Northern Europe and Asia, and seem to have made their way across Behring Strait into Alaska, and then south and east. Quite a number of our species of insects can be traced back to their native homes in the eastern hemisphere by the course just indicated, and while some of them have remained confined to the Pacific Slope, others have pushed broadly to the east and may now be found from Greenland southward into New England. The Appalachian mountain system to the east forms a similar barrier to the westward progress of species introduced along the Atlantic Coast, except that there is a single gateway through which they gain admittance into the fertile plains of the Middle West. This is along the southern shore of Lake Erie, and between it and Lake Ontario, especially the former. It is within the portals of this huge gateway that we are now sitting, and species of insects introduced into the region about Quebec do not usually work their way westward to the north of Lake Ontario, but they first move to the southward into New England and New York, then westward, entering Canada again between Buffalo and the mouth of the Niagara River. The cabbage butterfly followed precisely this course of diffusion, while the two asparagus beetles, first introduced much farther to the southward in the United States, have spread up through New York and crossed the Niagara River into Canada in the same manner. The willow curculio is following the same course and there are many others that I have not time to mention. On our own side, the course of diffusion lies along the south shore of Lake Erie, across the northwest corner of Pennsylvania into northeastern Ohio, where they spread broadly to the westward, and to a lesser degree to the southward. Of the destructive insects that have traveled over this path of diffusion, one of the asparagus beetles, the willow curculio, clover root borer, clover leaf weevil, cabbage worm, and still others might be mentioned, all imported into this country from across the Atlantic. Thus we find that we can trace the path of diffusion of the most of our injurious insects either from distant portions of our own country or from other countries more or less remote, and having established themselves among us, have come to stay; and the warfare against them is to be an every-year experience in future.

There are two powerful natural elements that exert a continual restraining influence on nearly all insect pests, and it is when one or the other of these becomes temporarily inoperative that we are likely to experience widespread devastations among such as have become fully established among us. One of these influences is adverse meteorological conditions, and the other natural enemies, and they may be considered as regulating the abundance and destructiveness of insects by their direct influence on the pests themselves and also in the effects of the former upon the latter, for adverse meteorological influences on the natural enemies of any insect pests is decidedly advantageous to that pest, and it is thus relieved of one of its most powerful restraining influences.

It is a mistake to suppose that severely cold winters are detrimental to insects, as if the cold is continuous the effect is to their advantage if anything. You can freeze an insect once, in the northern parts of the country at any rate, and it will thaw out in the spring as healthy as it was in the fall, whereas a repetition of this is fatal. Thus it is the open winters, as we call them in the North, that are the most detrimental, though this is probably not as essentially true of the warmer portions of the country. In the North, the farmer can take advantage of this phase of the insect problem in many ways, some of which are equally applicable in the South. Very many species in the late fall betake themselves to matted grass, heaps of rubbish, fallen leaves and like places for protection from the cold of winter, and, besides, the effect of such covering is to in a measure counteract the effect of sudden changes of temperature. A warm sunny day in early spring does not thaw the ground thus covered, only to be frozen again at night, but rather serves to keep it continuously frozen until more settled warm weather. The Great Lakes in the same way protect the peach buds in Michigan, Ohio, and portions of Canada. Insects ensconced among this rubbish, or about the roots of vegetation growing there, are not subject to the full effects of the sudden changes that prevail in the open; but if the farmer takes the precaution to graze off this grass in the fall or burn over this protected area during winter, he removes this protection and either kills the insects outright, or else subjects them to the adverse effects of the weather. Again, the wire worms, cut worms, and grub worms, so disastrous everywhere to the Indian corn crop, feed upon the roots or lower stems of grasses until fall, when they burrow downward into the ground not in order to get below the frost line of winter, but to reach a point where they will escape the freezing and thawing of fluctuating temperatures. When the farmer fall-plows lands infested by these insects just before winter sets in, he not only breaks up these winter habitations, but throws up the ground so that the frost penetrates deeper than it otherwise would and it is subjected to this freezing and thawing that the insects have tried so hard to avoid. These three groups of insects breed naturally in grass lands, and in rotating from a grass to a corn crop they constitute the most destructive element in corn culture, but they can be met in a practical manner by simply fall plowing these lands, after they have prepared for the winter, when they become too torpid to prepare a second time or to burrow deeper to escape the effects of a changed condition of the soil above them. If the farmer would but examine the cocoons in which many insects pass the winter, he would find that there is an inner wall and an outer wall, between which is a more or less open work of threads, thus forming an air chamber that counteracts the sudden and radical changes of temperature and moisture, and he can apply this information in his business by seeking to disarrange the domestic affairs of insect pests as much as possible, espe-

cially in the late fall, and let the weather do the rest. While on the subject of burning grass and rubbish, I wish to call attention to the fact that the various species of rye grass that grow so luxuriantly along fences, ditches, and other waste places harbor myriads of the joint worms and straw worms that attack wheat, rye, and barley, doing very serious damage by causing the kernels of the grain to shrink and shrivel, resulting in a loss that not one farmer in one hundred or perhaps 500 would suspect was caused by insects, and which might have been saved by mowing off this grass in late June or burning it off in winter or early spring. The farmer who fall plows his grass lands is not only taking time by the forelock, so to speak, by getting his spring work done in advance of the season, but he is fighting insects in the most practical manner possible and several kinds at the same time and with the same measures. This does not apply wholly to the northern farmer, as fall plowing is one of the most practical and effective measures to apply against the cotton boll worm and the cotton boll weevil; while the burning over of waste lands in winter will if anything be more beneficial in the South than in the North, where we know it is of great value. Again, the modern wire fence is an important innovation from an insect point of view, as it requires a minimum amount of ground to grow up the grass and weeds, while the Osage orange hedge and the Virginia rail worm fence are the worst of all. It has been demonstrated in Iowa and Kansas, and is true elsewhere, that hedge fence with its outlying borders of neglected ground is one of the greatest protections possible to provide for helping the chinch bug through the winter, and the worm fence is its full equal in that respect. When I tell you that I have traced an outbreak of chinch bug in a wheat field to the shocks of fodder that were allowed to stand over winter therein, you will understand the significance of a half mile of hedge or worm fence. The plum curculio finds just the winter quarters that it desires in such places, and the same is true of many other insects. The farmer that fall plows and cleans up his premises in the fall or early winter is fighting insects in the most practical manner possible, because he is not only dealing a terrific blow to his enemies in advance, but he is making the weather help him in his warfare.

The next practical method of fighting insect pests is by a rotation of crops, in itself a most excellent factor in good husbandry, but less applicable to the orchardist than to the farmer, though even the strawberry grower has found it advantageous to grow but one or at most two crops of fruit on the same ground, without changing for a year or two to some other crop. The fact is, Nature rotates her crops but rarely, and insects that, through ages, have been dependent upon them for food have come to hatch, develop, reproduce, and die in accordance with the growth, development and death of the plants which they inhabit; the plants have become fixed in habits and location, and so have they, and they cannot charge in a day to meet the adversities that may be thrown in their way by the twentieth century, up-to-date farmer.

The female insect that produces the cut worm, the female that gives rise to the wire worm, the parent of the white grub, the mother of the corn root worm, and the mothers of many other insects can only protect their offspring by placing their eggs where there is the greatest probability of an ample supply of food, and they can only presuppose the future by the present and past. These insects have been following a course for centuries and cannot change to meet the requirements of a rotation of crop which is to the highest degree unnatural and to them unlooked for. Therefore, if they deposit their eggs among the plants of their natural food, and the farmer suddenly displaces this with another, upon which they cannot subsist, death is inevitable. Again, if on reaching the adult stage, the mother insect must undertake a long journey in order to find the proper food supply for her future offspring, there are more than likely to be terrible disasters awaiting her on the way, so that of the many that may set out on the journey, there may be few that will reach the desired end. If the Hessian fly, the wheat midge, and other equally frail insects happen to emerge and be obliged to migrate during a storm or heavy gale, the possibility is that a very small percentage will survive the ordeal; whereas, if they have not to go more than a few feet or yards, that is if they do not have to leave the field in which they originated, the casualties will probably be few. To such an extent do these factors enter into account with insects that in many cases the female is totally wingless, as is illustrated by the wheat straw worm, *Isosoma grande*, one generation of which is wingless in the adult stage; the female of the canker worm-moth, the female of the strawberry crown borer, and we even have a form of the notorious chinch bug whose wings are so abortive that they are useless to the possessor. Of course, the weather at time of the emerging of winged adults of many species may be favorable to them, and they may be able to travel long distances, but the farmer or small fruit grower who forces them to do this regardless of meteorological conditions, will reap great benefits from obliging such travels, as very often the weather will aid him in his contest. Again, if a field of corn is badly infested by the corn root worm, the mother insect deposits her eggs about the roots of the plant in September with the expectation that the same kind of plant will grow up there another year; but the farmer changes the crop to one of the smaller grains, and what is the result? As soon as the young hatch the following June and attempt to feed, they find no roots upon which they can subsist, and they are totally exterminated by starvation. If the Hessian fly when it emerges in September or October, according to latitude, can find no wheat plants above ground, her progeny will die from lack of food, because they cannot survive on any other plant. Imagine the sensations of cut worms, wire worms, and the white grub when they go into winter quarters in a luxuriant meadow, and the few that do survive the weather wake up in a plowed field with no food in sight! The farmer that rotates his crops is engaging the assistance of nature in advance to help him in his conflict with insect pests. The stock raiser and dairyman do not like to rotate their pastures and meadows, but chinch bugs and bill bugs are compelling them to do so, for if allowed to revel in permanent pastures they soon begin to curtail the grass crop, and if it should be timothy grass, they may soon kill it out entirely, for they seem to work the greatest injury in timothy meadows and pastures, whereas if these were subjected to a system of rotation this would not occur. I have known of instances where the short-winged form of the chinch bug was rendered practically harmless by a general rotation of the grass lands in a certain community. In the Middle West, the underdraining of swamps and the bringing of these under cultivation is coming to be a serious problem, as when the swamp vegetation is removed and replaced by corn, the insect inhabitants of these attack the corn plants and destroy them. The pests cannot breed in corn, and the second year they have disappeared, but thousands of acres of corn are destroyed in some States by attempting to grow it immediately after breaking up these reclaimed swamp lands. The remedy is not difficult to apply, and consists in killing out all of the swamp vegetation by fall plowing, and the destruction of all stray plants early in spring, while the planting may be delayed until late in May.

Crop rotation is one of the most effective measures that can be applied against the Hessian fly, because it forces the frail adults to journey from one field to another, many times when, owing to unfavorable weather, the most of them must perish on the way. By far the most practical and efficient measure is late seeding. This was first worked out and applied systematically by myself in Indiana while in the employ of the United States Department of Agriculture, back in the '80s; but it has since been demonstrated from Kansas to the Atlantic Coast that it is by far the most effective measure that can be applied, and that it is possible for any farmer by watching the insect and the seasons, to so time his sowing as to have his wheat come up just after the flies have come and gone. The flies come forth from the stubble in which they have passed the summer at times varying with the latitude and weather, the time being later to the south and earlier to the north, living but a few days and then dying. Thousands of wheat growers are taking advantage of this and do not sow until the flies have disappeared. This in the latitude of Chicago will be about September 10 to 15, while in the latitude of Cincinnati it will be about the first week in October; but the exact time varies with the weather during the few weeks previous. The same meteorological conditions, that is lack of moisture, that will prevent the starting of the young wheat plants will also retard the appearance of the fly, so that every farmer must work out the problem of the time to sow wheat in the fall for himself, and for his own neighborhood. A warm fall extending into December, as it sometimes does, is favorable to the development of the fly, not that it increases their number at that time, but it enables a greater number of the young to become sufficiently advanced to pass the winter in safety, and the increase in numbers follows the next spring. This is why there are sometimes comparatively few in the fall and so many more in the spring, and a few early-sown fields will be sufficient to stock the whole neighborhood where they are located. I say each farmer must hear, think, and act for himself, because a few years ago we had the spectacle of a certain experiment station director going out, just at the time wheat in his locality ought to be sown, and seeing a fly deposit her eggs, rushing off associate press dispatches to a half dozen States regardless of location, urging farmers not to sow their wheat and to plow up that already sown, when there was at that time no danger of Hessian fly, and the following year showed that there was no danger to be avoided even in the field where the one female was observed threatening to devastate the country by laying a few eggs. By rotation of crop, thorough preparation of the seed bed, sowing at the proper time and the free use of phosphates, where commercial fertilizers are required, any farmer can ordinarily avoid the fly; but the thing that he cannot do is to prevent his neighbor disregarding all of these things and breeding flies enough to overrun the neighborhood the following spring.

Generally speaking, there is usually some way whereby the husbandman can ward off insect attack upon his crops, but it is necessary that he first know what it is he wishes to overcome, next what to do, and do it at the proper time and in a proper manner. If these suggestions were followed that $300,000,000 annual loss would be greatly reduced. But so long as those engaged in the production of grains, fruits, and other agricultural products do not cultivate a business acquaintance with these pests it cannot be expected that this enormous loss will be reduced, but rather that it will increase if anything. It is of comparatively little use for the official entomologist to attempt to reach the masses direct. This must be done through the influence of representative farmers, such as I have before me. It is you that must take the initiative, and the rest will gradually follow. Insects go through their life cycle about as regularly as clockwork, and if you wish to hit them at any particular point in their life history, at least during the warmer months, you must be on time with your application; you must spray when the proper time comes and not a week or two earlier or as much later, simply because you were too busy to do it at the right time. If you wait to see what an insect is going to do, the probability is that by the time you find out it will be too late to use your remedy. Remember that you can fight insects by good farming better than in any other way. The insect problem is a big one and must be handled as such, and not as if it was a small feature of your business. Their effect is so insidious that more than ordinary watchfulness is necessary in order to detect the leak and save the leakage by removing the cause thereof.

Twenty years and more ago there was an insect known along the Mississippi River as the buffalo gnat, that, during some years killed enormous numbers of live stock of all descriptions, and sometimes a human being fell a victim of the pest. A single county in west Tennessee suffered a loss in live stock amounting to half a million dollars in a single season, and in Louisiana 3,500 head of stock were killed in a single week in one parish. Acting under instructions from the Department of Agriculture at Washington, I spent a portion of three years in investigating the trouble and found that it was primarily due to the fact that these gnats bred in spring in running water and an overflow of the river at a certain time enabled them to breed in millions in what was ordinarily little more than a ravine. The levees were rebuilt and the old breaks in them closed up so as to prevent the influx into the low or swamp lands of river water, and there has been no serious trouble since. Formerly these insects were sometimes present in such numbers as to prevent the running of the horse cars in Memphis, but since the country along the St. Francis River has been protected from overflow by the new levee, the pest has not occurred in that country to any serious degree. I cite this last illustration to show the necessity of unity of action in fighting insects that range over wide territory. The individual can accomplish but little as compared with what might be done by concerted action. The codling moth costs the State of New York several millions of dollars each year, and how many apple growers spray systematically and spray right? What is true in New York is true in New England, Ohio, and Illinois. Talk about taxation! Here is a tax paid every year that would cancel the entire interest-bearing debt of the United States in three years, and it is paid by the husbandman alone. We cannot prevent all of this loss, but intelligently directed action will save an enormous amount, the most of which is now a total loss, largely through a lack of easily acquired knowledge of the causes and intelligent application of the requisite measures of relief.

FAMILY GROUP OF HUPA INDIANS.

A FAMILY GROUP OF HUPA INDIANS.

THE Hupa Indians, of which our picture, taken from the Report of the U. S. National Museum, shows a group, inhabit the valley of the same name in northwestern California. They represent in series of family groups the mixed tribes of California and Oregon. Physically the Hupa stand between the large-bodied Sioux and the under-sized Pueblo Indians. In language they belong to the Athapascan family in common with the Tinné of Canada and the Apache and Navajo of Arizona. They live on a mixed diet of meat, fish, and acorns; dress in deerskin, and are fond of per-

sonal ornament. Their better houses are of cedar planks and the floor is slightly sunken beneath the surface of the ground. An important industry among them is the harvesting, transporting, storing, and milling of acorns, together with the preparation of food from the meal.

GOVERNING GAS AND GASOLINE ENGINES.*

By DUGALD CLERK, M.I.C.E., F.C.S.

THE governing of a steam engine is a very simple matter compared to the governing of an internal-combustion engine of any type.

The first gas engine which appeared upon the market was the well-known Lenoir engine, which was invented in 1860, and it is interesting to find that the steam engine method of governing was followed. The governor is of the old-fashioned centrifugal type, and it operates, by means of a lever and link, a throttle valve placed on the gas supply pipe. It was soon found, however, that governing by throttling the gas supply alone was an exceedingly expensive and wasteful method of operation. The reason of this is that gas and air mixtures can only be ignited within certain limited proportions, and any excess of gas on the one hand, or excess of air on the other hand, between these proportions only results in a missed ignition.

The Lenoir engine did not succeed on the market, and the first engine to make something of a success was the Otto & Langen, which appeared six years later. This engine was governed by reducing the number of impulses in accordance with the work required. This engine in time gave place to the well-known compression engine operating on the Otto cycle, which was invented in 1876 by the late Dr. Otto, and introduced into this country late in 1877. This engine was also governed by missing impulses; that is, the governor operated to either admit the whole gas supply, giving a full explosion, or cut off the whole supply, giving no explosion. This method of governing has, up to now, been found to be the most economical for gas engines of moderate size.

Although this hit-and-miss method of governing, as it has been called, is the best from the point of view of economy in gas consumption at light loads, yet it has been found to be mechanically inferior to other methods of governing when great steadiness of revolution is required.

About 1894 Messrs. Fielding and Platt, of Gloucester, introduced into their electric lighting "Otto" cycle gas engines a method of governing which consisted in throttling both the air and gas supply in such a manner as to admit of a gaseous mixture of uniform composition at all loads, so far as the proportion of gas to air is concerned, but allowing the engine to get a smaller and smaller volume of gaseous mixture as the load diminished. By this arrangement the compression in the engine cylinder was reduced as the load became lighter, and the number of impulses were kept up without interruption, and greater steadiness thus resulted. Messrs. Priestman, of Hull, also introduced this method of governing to control their heavy oil engines; and very many of the engines built by them govern in this way.

When Daimler first produced his small gasoline engine, he governed by missing impulses. It was difficult for him to govern by cutting off the liquid fuel supply in the way that a gas engine cuts off the gas supply. As he had used an atmospheric admission valve to the engine cylinder, he therefore governed by means of the exhaust valve. He applied the governor to the exhaust valve spindle in such a manner that when the speed rose the governor pulled out the knife edge opening the exhaust valve, and left the exhaust valve closed.

This method of operation proved unsatisfactory, but it was the method of governing which was almost universal until about two years ago. The charge throttle method of governing was introduced a little before that time, and now it may be said to be almost universal. This method of governing has the great advantage of maintaining the full frequency of impulses, and graduating the power of the impulses within practically any required limits. Another method of controlling the impulse now in use consists in varying the moment of beginning the ignition. As a governing method this is an extremely bad one. If an engine be controlled by advance and retard sparking, the consumption of fuel remains practically constant for all loads, and no economy is obtained by running at light loads; and, further, the exhaust valve and exhaust pipe are liable to serious overheating.

The evil of attempting to control for any length of time by retarding the spark is readily seen in any four-cylinder gasoline engine. If the engine be run with the throttle full open at a light load for even ten minutes, controlling the speed only by retarding spark, the exhaust pipe rapidly rises to a good red heat; and the exhaust valves, although one cannot see them, must be also red-hot. The retard spark method of controlling an engine is a most mischievous way, and all gasoline engines should be designed so that the full range of controlling can be accomplished by throttling the charge. Variation in the timing of the spark should only be resorted to when it is desired to drop or raise the speed of the motor; and so it is necessary to retard the spark in order to avoid too early or late ignition.

Although the method of throttling the total charge is the easiest of application in practice, and perhaps at present the most satisfactory method of governing, yet it seems to me there is another method of operation which is superior to it in many theoretical and practical respects. The fall of compression required by the throttle method of governing results in an increase of gasoline consumption per indicated horse power obtained, and this would be avoided if the compression could be kept constant by admitting the air charge during the whole inlet stroke of the engine, and varying the time of admission of the gasoline so as to come later and later in the stroke, as the engine became less and less loaded. Such a method of operation, however, introduces difficulties in maintaining constancy of proportion of gasoline to air, and it requires care in shaping the combustion chamber so as to make certain to have mixture of standard strength near the ignition point. For such governing, a somewhat long combustion space is required. In governing of this kind, too, very effective proportioning of gasoline to air is required, and a thoroughly effective mixing of the gasoline with the air, however small the volume of gasoline introduced. Governing of this kind, however, has the advantage that at light loads the mean temperature of the gases filling the cylinder is greatly reduced, and the economy of gasoline for equal power would be as good at light loads as at heavy loads.

A governing cycle of this type is that followed by the De Dion engine. In that engine, as you all know, the governing is performed by retaining a portion of the exhaust gases in the cylinder. By this method the compression is kept up to a very considerable extent, and the volume of admitted charge varied. This control works very well, as you know, and gives and maintains an impulse every cycle under very light loads. It seems to me, however, to have several objections, in that the hot exhaust gases are mixed with the incoming cold charge, and the mixture compressed is very hot to begin with. This, of course, leads to loss of gasoline when running at light loads, as the added heat to produce a diagram area begins at a much higher temperature, and therefore requires a larger heat loss.

Although the governing of the gasoline engine is now fairly satisfactory, yet there is still much room for improvement. At very light loads, throttle governing is apt to be somewhat unstable, and impulse changes occur in the cylinder independently of the movement of the controlling or governing lever. To produce the best possible governing, the first thing required is certainty of the proportion of combustible mixture at all speeds and loads. This is a question, of course, of the carbureter. The second appears to be certainty of ignition within the cylinder, not only as to firing or not firing, but as to firing exactly at the same time, and attaining the same maximum temperature at an equal movement of the piston. This requires good mixing, and at light loads as little mixing as possible of the combustible charge with the exhaust products in the combustion space of the cylinder. In the event of varying the speed greatly, it also requires some accurate mode of retarding or advancing the spark to keep the diagram always rising to a maximum at the compression end of the stroke at all speeds. In most cases this is done at present by a somewhat haphazard hand-operated arrangement. The best governing also seems to me to require constant compression and constant low temperature of the charge before compression. In addition to this, of course, to obtain a governor which does not hunt, the mechanism of the governor must be arranged for stability, and possibly some dashpot arrangement introduced to prevent the governor acting too quickly. I have confined myself, however, to the heat fluid part of the problem to-night, and do not intend to enter at all into mechanical questions.—The Automotor Journal.

* Excerpts from a paper (which was accompanied by illustrations and diagrams) read at a meeting of members of the Automobile Club of Great Britain and Ireland on Thursday, October 22, 1903.

CAVE EXPLORATION IN CALIFORNIA.

PROF. JOHN C. MERRIAM, of the geological department of the University of California, in speaking in Berkeley on the exploration and excavation of caves now in process in that State said: "Though our ancestors believed all caves to have been the habitation of gnomes and dragons, and engaged in knightly quests to kill them, modern science has rid the world of all such pests much more effectively. But it gives us other mysteries and other fields to investigate, and the caves remain as interesting as ever. They furnish data to build up such subjects as geology, palæontology, biology, and archæology, but perhaps the most valuable cave research lies in the field of archæology, which gives us the history of man in his 50,000 years on earth. In this direction the most satisfactory work has been done by the European scientists, and we follow their methods very closely. California cave exploration began with the study of the caverns in Tuolumne and Calaveras counties, where the limestone strata are peculiarly plentiful and rich in material. In the early '60s State geological parties investigated a number of these and found human remains so plentiful that they were led to the theory that the caves must have been Indian burying places. It is very possible that such was the actual case.

"In estimating the chances of finding our prehistoric man we have every reason to expect that, with careful and painstaking exploration and excavation that understands the methods and appreciates the value of the material and its occurrence, our labors will be crowned with success. In regard to the undefined material already in our possession little can be said. We have some implement-like bones that are of extraordinary interest. If they are genuine, they furnish some of the most satisfactory proofs of man's age in America that have yet been obtained. If only water worn, they are still an interesting chapter from the history of life in this part of the world. And the man himself we may find in some other cave, the history of which may be read by the record being obtained at Potter."

THE CONDOR.

THE condor of the Andes, known to scientists as *Sarcorhamphus gryphus* (*Linn.*), is one of the largest birds of flight, and probably occupies the first place among the land birds. This huge American vulture ranges over a large portion of the South Andes, and is restricted mainly to the Andes, where it ascends to heights not reached by any other creature. The condor is of slow growth, requiring about seven years to attain the full plumage shown by the specimen in our illustration. The young birds are unable to fly for more than a year after hatching. Many tales, most of them of doubtful veracity, are told of the creature's rapacity. The size of the condor has been much exaggerated; it is not known to exceed nine feet in stretch of wings, and is little over three feet in length. Our illustration comes from a recent report of the U. S. National Museum.

THE CONDOR.

CONCERNING COLORING, GILDING, SILVERING, AND OXIDIZING.

IN every process of artificial metal coloring, it is not only a question of the color to be obtained, but in most cases how the colored surface will afterward appear—frosted, bright, dead gloss, or dull. Brightly polished gold will show upon the metallic surface, even after the coloring, that it was previously polished. The frosting which the decomposition of the coloring matter produces upon the surface is often just what the operator desired, and if not, it may be readily attained by the use of the frosting brush; but the dead appearance would be deeper and more pronounced if the surface had been frosted before the coloring.

With silver, it is customary to make use of the sharp frosting-brush before the last blanching.

Less care is taken in the matter of previous preparation when the objects are to be oxidized. But just in these cases is it of great importance. The so-called "decappage" should not consist merely of cleansing, but

the surface of the object should be brought, before the "decappage," to the appearance which the finished product will present.

A piece of silver that is intended to appear old may indeed, by dint of much work upon it with polishing powders, be brought, after it has been oxidized, to resemble an ancient piece so closely as to deceive even a practiced eye at a distance or surpass the knowledge of a layman under close scrutiny; but when examined minutely by an expert, it will never impose upon him so long as the workmanship upon the whole object plainly discloses that it was from the beginning not a finished piece.

Our predecessors were not given to displaying in their best rooms objects of art which were tarnished, imperfect, or covered with dust. With them, what was gold glittered, and ornamental pieces served to ornament; these were kept like new, polished inside and out, washed and constantly cleaned. Above all, each object was brought to the highest state of perfection when it was new. If then the intention is to imitate antiques, the present-day workman will come nearer to a successful completion of the task if he make his work as perfect as did the goldsmith who, living centuries before, catered to the tastes of customers of his time.

They were burnished, gilded in part, polished—in a word, finished.

Such a piece will indeed take on the marks of age if it be handled only as the ignorant, careless servants of three or four generations ago might have handled it. But of course it must be done by a much quicker process. By artificial methods, and in the shortest time possible, too, we can now spoil what, with unintelligent treatment, it took a hundred or more years to spoil. We ruin the polish, the gilding, and the pickling or dipping.

Quite differently do we proceed with the modern antique. Upon its exterior this must show that it is new. Its color is not an accident brought about by the lapse of time, nor must it be so considered. It is rather an appointed task, an artificial product, and must therefore fulfill its requirements, which are that it present the very best in this regard that may be demanded from artisans of new and modern times. From the first blush it must be strikingly apparent that the operator understood how to oxidize, that he learned the art; and no one will deny that the art of oxidizing must be laboriously acquired.

To make a piece merely hideous is by no means the same thing as oxidizing it! The piece should not be gray, or speckled over with ugly black blotches, but it should rather possess a determined, a pronounced ground, a certain color tone. Upon a piece which shows the casting-skin, the marks of the file and the scraper in its depressions, and false hammer strokes upon its highest places; on which in places the pickling is ground through, etc., such a color tone is not to be attained, but only upon a piece which in all respects is well worked out and highly finished, one which shows chiefly upon its outer surface, not only an even mixture of the metals, but also a treatment previously decided upon for the attainment of the desired effect.

Chemical purity of the surface is a most important condition, but what has just been said is almost equally essential.

The color of the oxidized surface, whether light gray or almost black, depends upon what means are employed for the work, and whether or not the operation is to be crowned with success, depends upon how it is performed. As a usual thing, this is just the part which receives little consideration and unjustly so. The fashions of the day and the trend of the styles make heavy demands upon the coloring of the goldsmith's work. Just as a conscientious goldsmith would rather alloy his gold himself, melt it, select his own diamonds, so he too should have the last hand in the finished work or delegate it to that conscientious employe best adapted for it. Electro gold-plating demands practice, accuracy, and patience; this is none the less true of oxidizing.

If ammonium sulphide be selected as the best medium for procuring the desired oxide, then do not make use of half-exhausted chemicals, but take them fresh and of unreduced strength. Thin down the solution well with pure lukewarm water (distilled water is the best) at a temperature of from 20 deg. to 25 deg. R. (77 deg. to 88 deg. F.). By all means avoid touching the piece with the hands. Place the piece in the oxidizing fluid, where it begins, and wait till the color reaches the desired tone. Do not add ammonium sulphide while the piece is in the solution, but first remove it, add the sulphide, stir the mixture carefully, and hang the piece in again.

When the color-tone is reached, remove the piece, rinse it well in clear water, and dry it in sawdust; or if it should need further treatment, whereby the oxide on the higher places might be made a little lighter or even quite bright, it may be brushed with water and whiting, or even very finely pulverized pumice stone may be used with a soft brush delicately and without scouring.

In this piecemeal removal of the darkened oxidized surface lies the whole of the art of good oxidizing. If, however, the preparatory work has not been carried forward with sufficient care, even this later process will be of little avail. The magnificent tone-reductions on the French bronzes, medals, and plaques are attained only because the workmen lay great weight upon these apparently inconsiderable side issues.

The treatment with the sand blast is especially recommended when a very fine grain is desired.—Translated from Die Edelmetall-Industrie.

It is reported that an Anglo-French company is being formed to build ferryboats, of a length of over 300 feet and a beam of from 30 feet to 50 feet, for carrying trains across the Channel between Calais and Dover, so that passengers will be able to make the journey between Paris and London without changing carriages. It is, however, in the transport of fruit, flowers, and vegetables that the ferry is expected to prove of great advantage. By the saving of time effected in the conveyance of goods from the South of France to England without breaking bulk, markets hitherto closed to the French producer will, it is expected, be open to him.

ENGINEERING NOTES.

The total area in the whole of India irrigated during the year 1901-2 fell just short of 20 million acres, which is the largest on record, and the value of crops raised thereon amounted to 42 crores, or nearly 95 per cent of the capital outlay expended on them.

One of the most durable woods is sycamore. A statue made from it, now in the museum of Gizeh, at Cairo, is known to be nearly 6,000 years old. Notwithstanding this great age, it is asserted that the wood itself is entirely sound and natural in appearance.

According to statistics issued by the French Ministry of Finance, the number of cycles in use last year amounted to 1,206,742, or about 100,000 more than in 1901. Since 1894, when they numbered 203,000, they have increased about six-fold. With regard to their distribution, Paris and its environs absorb 318,000.

The Trinity House authorities have given notice of several important alterations at the lighthouses on the south coast of England and in the English Channel. The one of the greatest importance to all mariners concerned in the navigation of the Channel is that which relates to the Lizard Lighthouses. Here the two fixed white lights hitherto exhibited have been discontinued, and in lieu thereof a white electric light, of great brilliancy, is now exhibited from the eastern tower, flashing once every five seconds, and lasting only for about a quarter of a second. In addition a continuous light of small power may be visible for about twelve miles under certain circumstances. The subsidiary fixed white light proposed to be exhibited from the eastern tower will not be shown for the present.

What is said to be the most dangerous railway in the world is that recently completed up the side of Mt. Vesuvius for the benefit of the many tourists that annually visit this famous volcano. It is a cable railway of the mono-rail type, the one car comprising the active rolling stock being supported by two wheels, one at each end of the car. The center of gravity of the car is below the top of the supporting rail, so that it balances without the aid of supporting wheels at the sides. The railway line runs to within nominally 1,000 feet of the crater mouth, but the distance changes from day to day on account of the rapid changes that take place; accretions to the sides of the crater may materially increase the distance one day, and the fall of a huge slice into the seething gulf 500 feet below may considerably lessen the distance the next day. The maintenance of the line in proper alignment is a difficult matter. Fissures opening, the flow of lava, falling cinders, and sliding of the roadbed require constant watchfulness and labor by gangs of laborers who constantly patrol it during the periods of operation. The "train" has no fixed time-table, the trips depending on the activity of the volcano and direction of the wind; some days they are entirely abandoned.—Machinery.

Mr. William Odell, before Section G of the British Association Southport meeting, described some experiments which he has made with the object of finding a convenient method of determining the power wasted by the windage of flywheels and dynamo armatures. The experiments were made with paper disks, which were mounted on the shaft of an electric motor. The excitation was kept constant, so that the torque was proportional to the current. Thus the extra current required to maintain a given speed after the disk had been fixed to the shaft gave the torque absorbed by the disk. There was found to be an angular speed for each disk above which the torque was accurately proportional to about the 2.5th power of the speed. This critical speed appeared to vary inversely as the square of the diameter. Below it the law followed was of a lower degree; but owing to the multiplication of errors of measurement no definite conclusion as to its exact nature was arrived at. As the three disks originally tried gave uncertain results as to the effects of size, a much larger one, nearly 4 feet in diameter, was also tried, and as a result of all the experiments it was concluded that the torque varies as about the 5.5th power of the diameter. To give an idea of the amount of power thus absorbed, it may be stated that a disk of 47 inches required 1-10 horse power to keep up a constant speed of 500 revolutions per minute, and that if the above law holds, a 9-foot disk would absorb 10 horse power at the same speed.

Ferro-concrete piles have just been used in the construction of the new law courts at Berlin-Wedding. They have been largely employed in getting in the foundations, which are placed in poor and treacherous ground, with a very unstable coefficient of resistance. After many trials, it was determined to adopt piles of triangular section, with the corner cut off. They are composed of clean, hard, river ballast and Portland cement of the best quality, in the proportion of one part of the latter to three of the former. Their length varies from 17 to 26 feet. The armature consists of three iron rods tied together at regular vertical distances by eye rods, spaced every 10 inches, having a diameter of a quarter of an inch, and set into the concrete, with a blunt point at their lower ends.

According to the Centralblatt der Bauverwaltung, the concrete, slightly wet, is carefully prepared in a pug mill and deposited in vertical wooden molds in layers 8 inches in thickness, subsequently reduced by pressure to about half that size. Before fixing the tie-rods and adding fresh doses of béton, the surface of each preceding layer is roughened, so as to insure a thorough mixture and incorporation of the whole mass. Thus manufactured, the pile is left for a period varying from twelve to twenty-four hours. During the next seven or eight days it is watered constantly and abundantly. It is then taken out of the mold and again watered for the next eight or ten days and becomes sufficiently hardened and consolidated to be safely transported to the site of the works. The piles are allowed to remain in this condition for about a month, when they are fit to be driven, which operation is effected by means of a steam pile driver, with a ram weighing 2.5 tons. To prevent the heads being damaged by the fall, which is 5 feet 6 inches, they are protected by a buffer, built up of sheets of lead, plates of iron, and timber packing, all held together by an iron ring. Special arrangements are made for guiding the piles in their descent.

ELECTRICAL NOTES.

The Post Office Department of England has decided to make experiments with the American De Forest system of wireless telegraphy from Ireland to Holyhead.

The canal towage system now in general use—running an automotor on the path along the canal—requires a very good path and is expensive in the cost of road construction and upkeep; besides there are unavoidable vibrations of the engine. With two rails the roadbed construction is less expensive, but the adhesion is not sufficient for dragging heavy boats, except with very heavy engines. Still greater economy in roadbed construction is effected if a single rail be used, but there still remains the adhesion difficulty. An idea of Fabre, described in one of the May numbers of the Zeitschrift für Elektrotechnik, seems to overcome the difficulty by employing two-axle pairs, inclined against one another, instead of the usual two-wheel axles, each with two vertical axles. A wheel is mounted on each axle, and each pair of two wheels grips the single rail. The engine is supported by one broad, lateral wheel, which runs on the road, the object aimed at being to increase the adhesion and stability of the engine. Comparing the cost of this system with that of three other designs which competed for the Teltow Canal, and assuming 12 pfennigs (3 cents) per kilowatt hour as the cost of working, the capital expenditure is 2,500,000 marks ($595,000) for the Siemens & Halske system, 2,597,000 marks ($618,086) for the Rudolf system, and 1,007,980 marks ($239,900) for the Ganz system. The cost of working per ton kilometer is 1.07 pfennigs (one-fourth of 1 cent) for the Siemens & Halske, 0.667 pfennig (one-sixth of 1 cent) for the Feldmann & Zehme, 0.61 pfennig (one-ninth of 1 cent) for the Rudolf, and 0.413 pfennig (one-tenth of 1 cent) for the Ganz system.

Before the recent Copenhagen technical congress Prof. P. La Tour read a paper in which he gave the results of his investigations on this subject. The professor has for many years been engaged on behalf of the Danish government in experiments on the use of wind motors in connection with the operation of electric generating plants, and the results are stated to be fairly satisfactory. The main drawback has been the difficulty in obtaining approximately constant speeds, irrespective of the strength of the wind. It is reported that this difficulty has been overcome by the use of an intermediate shaft placed on a sort of balance, the transmission belt from the windmill leading horizontally down to the pulley of this shaft, and the pressure of the belt against it being regulated by means of the balance provided with convenient counterweights. From the intermediate shaft another belt leads to the dynamo, it being found practicable by this arrangement to make the transmission belt from the mill slip on the pulley as soon as the load exceeds a given value, enabling the mill to run at any speed without carrying the speed of the dynamo above a certain limit. By means of this arrangement in connection with a maximum and minimum interrupter, inserting the machine automatically as soon as conditions are favorable, and switching it off again as the wind becomes too weak, the author claims to have obtained excellent results, the plant having proven satisfactory even during the strongest storms. As a matter of course, storage batteries are always used in connection with such plants. A small station equipped according to this plan is said to have been in operation at Askoo, Denmark, ever since October, 1902, about 450 incandescent lamps being lighted with excellent results; a petroleum motor is provided as a reserve in case of several days' calm weather.

When fatalities or damages seemingly attributable to electricity occur, the popular belief is that electricity itself, as a force, is directly responsible for them. In fact, however, there are few forces of nature that are less harmful in themselves than electricity. The damage done by flood or tornado, for instance, is done directly by the water or the air. But electricity, when it works, usually does so indirectly or by setting another of nature's forces into operation. An exception to this may be where the victim may have been so weak, physiologically, that a simple fall from a chair might have had a similar result. But in the majority of cases death from electric shock is shown to be due to well-defined chemical changes in the blood or tissues, due to the electric current. The damage done also to gas and water pipes by electrolysis, while primarily occasioned, it is true, by the escape of electricity from electric railway circuits, is not directly due to that force, but rather to a secondary action, and that a purely chemical one, namely, the setting free by electrical action of certain elements, such as chlorine and sodium, constituents of a saline solution in the soil, which attack and corrode the iron pipes. Without some such solution in the soil there would be no such thing as electrolysis. Also, when lightning strikes a tree and shatters it, the result is not due directly to electricity, and not even to the electric current, but rather to the intense heat which the electric current generates in passing through the tree, which heat suddenly converts the sap into steam, and the latter in expanding, if the force be sufficient, tears the tree to pieces. If the force is not sufficiently powerful, the effect may be only to loosen the bark of the tree in places, the evidence of which may last for years, but may not be otherwise hurtful to the tree's growth. So far, indeed, from electricity being necessarily fatal to animal or vegetable life, it is well known that in proper quantities it is decidedly beneficial, and, when properly applied, acts as a stimulus to vegetation. An excess of current, however, will also kill vegetation. In both of these cases its action is due to the chemical changes which it effects in the growing plant or tree. The injuries to shade trees by contact with wires carrying heavy currents, such as electric light or traction wires, is mostly mechanical, an arc forming at the point of contact of the wire with the branch or limb and burning away the wood, leaving the tree stunted at such places. In very stormy, wet weather, it is not uncommon to have large trees set on fire by the escape of current from abutting electric light wires, the rain, paradoxical as it may seem, by

improving the conductivity of the circuit down the tree to the earth, virtually adding fuel to the flames.—Cassier's Magazine.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Ludwigshafen Industrial Exposition.—As a part of its first semi-centennial celebration, the Bavarian town of Ludwigshafen, on the Rhine, has given for some weeks past an interesting industrial exhibition. The town has grown in fifty years from a village of about 1,000 inhabitants to a flourishing city of 72,000. It is now the fifth city of Bavaria in population and the largest city of the Palatinate. Its Rhine commerce amounted in 1901 to 1,763,000 tons.

The exposition, which is intended to be local in its character, includes especially articles manufactured in the city or for the sale of which agencies are established there. Among the noticeable features of the exposition are, first of all, the extent and variety of the exhibits. Power is supplied by the management and looms and wood-working and other machinery are exhibited in operation. An American observer would notice among other things:

1. The varied exhibits of Portland-cement work, paving and roofing tiles, and the excellent sewer pipe shown by the Deutsche Steinzeugwaarenfabrik für Canalisation und Chemische Industrie of Friedrichsfeld. The pipe has the characteristic thread-like grooves on the inside of the collar where the connections are made corresponding to similar grooves on the end to be inserted in the collar and suggesting the use of asphalt instead of cement at the connections.

2. The well-known types of American wood-working machinery and tools, such as spoke-turning lathes, band-saws, and braces and bits. American screw-drivers, saws, taps, dies, and drills are exhibited by local dealers.

3. The heavy and clumsy character of the native shovel, trowel, pick, rake, ax, auger, and other implements as compared with the American product. The wooden handles are larger and not generally of as good wood as are those used by American tool makers. The exhibits in these and other lines show the preference given in Germany to strength and durability in tools. The light American buggy, light driving harness, easily handled American plow, harrow, cultivator, and shovel plow, the 15 or 20 cent rake, to be used for a season or two and then replaced by a new one; none of these are likely to be as popular here in the near future as they have long been in the United States.

4. The excellent display of bath tubs, closets, and modern sanitary plumbing, a branch in which Germany is making marked progress.

5. The most interesting single exhibit of the exposition is that of the Badische Anilin und Soda Fabrik. This company is engaged chiefly in the manufacture of coal-tar dyestuffs, including artificial indigo, and has largely made Ludwigshafen what it is. The company exhibits photographs, models, charts, and statistics relating to their business. Their plant itself is regarded in Germany as a model in construction and management. The concern, now in existence for more than twenty-five years, has never had a labor trouble and claims an unusually large average term of employment among its men.

The following is taken from the statistics exhibited: "Area occupied by plant, 1,850,000 square meters (457 acres); office employes, 808; workmen, 7,458 (no women are employed); dynamos, for light and power, 11; electric motors, 297; telephone stations, 225; arc lights, 1,018; incandescent lamps, 15,000.

"Total consumption per year.—Raw material, 163,000 tons; coal, 516,000 tons (Krupp, at Essen, 843,494 tons); gas, 22,700,000 cubic meters (city of Mannheim, with 145,000 inhabitants, 9,924,705 cubic meters); water, 4,100,000 cubic meters (city of Mannheim used 4,044,670 cubic meters in 1902)."

The company owns 102 houses for office employes and 653 for workmen; 65 baths are provided for office employes, 534 for workmen, and 24 for women and children. To these are added a large casino with libraries and reading rooms, hospitals for employes and their families, girls' cooking and housekeeping school, etc.—H. W. Harris, Consul at Mannheim, Germany.

Opportunities for American Contractors.—The British and South African Export Gazette of August 7, 1903, says:

"The vivifying impulse to enterprise in the Transvaal and Orange River colonies which the peace settlement has brought forth is steadily permeating South Africa as a whole, and the maritime colonies are not the last to feel the impulse. Natal, as previously indicated, has already been responsive to it, and now is the turn of Cape Colony, the eastern ports of which are ahead of Cape Town, as usual, in answering to the call of up-to-date ideas.

"In November last year we chronicled the sanctioning by the Cape parliament of a vote of $1,745,613 for harbor improvement works at Port Elizabeth, and also gave the details of the objects of the disbursement. As we then pointed out, this sum was inadequate to realize certain important works, such as the increase of the jetty accommodations, etc. Over and above both these disbursements and projects, however, the authorities at Algoa Bay have at heart the desire to provide the port with a harbor which shall afford shelter for vessels in the case of such storms as that which swept the South African seaboard some months ago, and from which shipping lying in the open roadstead suffered so terribly. With this object in view, Mr. C. W. Methven, M.I.C.E., the well-known harbor expert, who has been consulted on so many South African ports, was invited by the harbor board to investigate and report on the practicability of opening up the mouth of the Zwartkops River for harbor purposes. His report is conclusive as to the feasibility of the project. He advocates the dredging of the river, the drainage and reclamation of the marshes along its shores, the construction of two breakwaters at the river mouth, and the building thereon of 3,700 feet of quayage, shedding, etc.

"The estimated cost of all the works required totals, in round figures, $6,813,100. After consideration and approval by the local authorities and by the government department concerned, parliamentary sanction to raise the necessary funds will be sought. Before this stage is reached the British manufacturer will probably have the opportunity of tendering for the major part of the multiplicity of materials, machinery and equipment required. In due course we shall announce the progress of this matter; but in the meanwhile the opening is afforded for steps to be taken, through representatives on the spot, to secure such further information regarding possible requirements as may be obtainable.

"It is understood that the construction of the railway to Lobatsi by the Krugersdorp-Rustenburg route has been finally decided upon. This will bring Bulawayo within two days of the Rand."

Beirut as a Trade Center.—Foreign papers are publishing reports of trade possibilities in Beirut. Among the articles for which that market is open are iron pipes, which sell well. English wares are winning their way against others that were found to be shamefully thin and weak. The pipes are sold according to diameters. Those of ordinay diameter, from one-fourth of an inch to 2 inches, bring an average price of 11d. (22 cents) per meter (39.37 inches), provided the average weight is 3 pounds per meter. The total imports are put down at 500 tons. There is also a field for sewing machines. The number imported is gradually increasing. Enameled ware is also wanted. Beirut's commercial importance is constantly increasing. In very early times, when the Romans held sway in Syria, it was the seat of a flourishing silk trade. Since the Suez Canal cut off the caravan trade that once went by way of Aleppo and Damascus to Bagdad and Mecca, Syrian commerce has turned naturally to Beirut, the safest of her harbors. Back of the city rise the mighty forests and hills of Lebanon, with the fertile plateau of Keboa behind them, and behind that the anti-Lebanon hills before one touches the plains of Damascus. In Beirut trade found only a fair harbor, but it found a population that had grown from 25,000 in 1860 to 140,000 in 1900.

It is the home of the Maronites, a people who are familiar with agriculture and house industries of all kinds, particularly silk spinning and weaving. The French began to build a magnificent road from Beirut to Damascus in 1857 and finished it in 1863. In 1894-1896 a railroad (the Beirut-Damascus) was built to Hauran, 248 kilometers (154 miles), 56 kilometers (35 miles) of which were over the Lebanon Mountains, by means of an inclined railway (toothed rails, etc.). From Hauran, as a center, other roads were run off into the interior, one of 188 kilometers (117 miles) to Hama, thus uniting the Bekaa plains with the sea. In 1893 an artificial harbor was built at Beirut, which was joined with the Damascus Railroad in 1903. The high charges for port and quay duties are damaging Beirut beyond its power of remedy. Other ports are coming into prominence. Tripoli, a few miles to the north of Beirut, with good roads into the interior, is advancing. The whole country is opening up and offers excellent opportunities for parties interested in the sale of many kinds of agricultural and industrial labor-saving machines.

German Opinion of American Statistical Work.—The Central Bureau for the Preparation of Commercial Treaties, at Berlin, has just published a bulletin in which it urges the establishment of a bureau for obtaining and giving information on commercial and economical conditions in foreign countries. The bureau calls attention to the movement lately inaugurated in Great Britain in which trade journals devote themselves to obtaining and publishing exhaustive information on existing trade conditions in certain countries. Thus English manufacturing and exporting circles have received valuable directing aid in extending their business relations with South Africa. The bureau's bulletin deplores the lack of such special information for German exporting interests, and it proposes to make strenuous efforts to partly supply this want by translating and publishing English export reports on South Africa. In editing these reports it will take for its model the monographic reports published by the Bureau of Statistics of the United States, which the bulletin says are exemplary, unequaled, and of great service to American merchants and manufacturers. Other trade bodies in Germany hold the same view. Last week I received an inquiry from the German Export Review, the leading journal of German export trade, as to how they could procure copies of these "monographic reports."—Simon W. Hanauer, Deputy Consul-General at Frankfort, Germany.

Porcelain Pipes for Waterworks.—The Meissen China Factory, in Saxony, is making water pipes for waterworks which, on account of the various advantages they have over iron and stone pipes, seem to be a promising article, although they are more expensive than the latter. These pipes are very thin and glazed, and are imbedded in iron pipes, the space between the two substances being filled up with cement. China being the best resisting pipe material that we know of, every guaranty is given for an unlimited life of the pipes; moreover, the absorbing of iron in the water, which is very frequent when iron pipes alone are used, is made altogether impossible. Furthermore, the iron pipes by having particles of iron absorbed by the water will corrode in the course of time, forming hydrated oxides of iron (Eisenoxydhydrate), which will stop up the tubes and finish by eating holes in the pipes. So far this drawback to iron water pipes has not been very frequently noticed, but it is very likely that we will hear more frequent complaints about them when time draws on and the pipes now in use become older. China pipes, with the average diameter of ordinary water pipes, will cost about 3,000 marks ($714) per mile; if produced in large quantities their price could probably be reduced a good deal. Anyway, they seem to be worthy of trial.—Oliver J. D. Hughes, Consul-General, Coburg, Germany.

Butter-Making Machinery in Canada.—Quebec and Ontario are the best butter-producing Provinces in the Dominion of Canada. One can hardly travel in any direction without seeing a creamery or cheese factory. Small farms are scarce; on the other hand, the acreage to a farm is generally 200 or more, most of which is given up to pasturing and the raising of hay and grain. The average number of cattle to a farm is 30 or more. Since the establishment of creameries at almost every hamlet or village in these Provinces the making of butter by hand has been done away with. I find that separators from the United States can compete with those of Canadian make, and as separators are on the free list I am surprised that our manufacturers have not taken advantage of this, as well as of the excellent market, to extend their trade in these Provinces. In Canada, I am convinced, there is a splendid field for our people to operate in. The Canadians, as a rule, are anxious to try our machinery, which is superior to their own, as well as cheaper in price, and I would suggest that our manufacturers send their salesmen to these Provinces to work up this trade.—Felix S. S. Johnson, Commercial Agent, Stanbridge, Canada.

American and German Sewing Machines in Japan.—The German press, in commenting on the sewing-machine trade in Japan, points out that the importation of American sewing machines into Japan has increased elevenfold over that of Germany since 1893, although the American machines command much higher prices than those made in Germany. The reason for this is said to be the superior management of American companies in their business methods, such as establishing depots and agencies all over Japan; keeping branches, where all parts of the machines can be obtained, in the chief business centers; selling on the installment plan to private persons and sending salesmen to every town and village. The papers admonish the German sewing-machine manufacturers to make more energetic efforts to dispute the American advance in Japan.—Simon W. Hanauer, Deputy Consul-General, Frankfort, Germany.

Boycotting the German-American Petroleum Company.—The Frankfurter Zeitung of September 10 prints a communication from Holzminden, dated September 7, which states that "the petroleum dealers publish a declaration in the official district paper, according to which they have pledged their word of honor not to buy any more from the German-American Petroleum Company, as it aspires to become a monopoly. In the discussions it has been mentioned that the government of Brunswick does not consider that the arrangements made by the German-American company for the retailers are in conformity with the provisions of the law, and that therefore the official order for their removal will be issued very shortly."—Richard Guenther, Consul-General, Frankfort, Germany.

Failure of the Tobacco Crop in Hanover.—Owing to the severe hailstorms in the Eichsfeld district of the Province of Hanover during the past summer, the tobacco crop has been almost entirely destroyed. Many of the farmers—in order to avoid the payment of the production tax—have waived all claims to their tobacco crops. At the fair which was held at Solingen last fall over 40,000 marks ($9,520) worth of tobacco was sold; this year, however, hardly a pound will be even offered for sale. As the tobacco crop was not insured, the farmers have sustained very considerable losses.—Brainard H. Warner, Jr., Consul, Leipzig, Germany.

Duty on Packages to Holland.—In a dispatch dated August 27, 1903, Stanford Newel, United States minister at The Hague, reports a royal order, which was to take effect August 16, 1903. The order says that "on account of the troubles in connection with the declaration and clearance of packages from foreign countries, a duty of 5 cents per package shall be levied, to be paid by the party to whom the package is addressed."

Loom Shuttles in Northern France.—I am asked by Mr. E. Levillain, 4bis. Rue de Florence, this city, if there is any important manufacturer of shuttles for looms who would like to be represented in Normandy. Mr. Levillain assures me he can furnish the very best references, and that he visits the most important houses of this district, as well as those of Roubaix, Paris, Lille, and other cities. Communications may be addressed direct to him.—Thornwell Haynes, Consul, Rouen, France.

Railway Tunnel in Manchuria.—The tunnel through Khingan Pass, Manchuria, will not be completed for another year. It will be some 10,000 feet in length. Many thousand Chinese are employed. Two tunnels are being cut, the upper one for removing débris. Considerable difficulty has been met with, but there is no doubt of its ultimate success, nor of the saving in time it will effect over the Chinese Eastern Railroad.—Richard T. Greener, Commercial Agent, Vladivostock, Siberia.

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No. 1809. November 24.—Reports: New German Tariff Schedules—Marknenkirchen Exports to the United States—Wages and Cost of Living in Germany—Regulating Trusts in Germany—Pending Commercial Treaties of Germany—Traffic on the Rhine in 1902—Notes: Forest Conservation in Europe—Community Stores in Germany—Mycenæan Marble—Origin of an Industry—American Fruit in Saxony—American Loom Shuttles in France.

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No. 1812. November 28.—Reports: *American Trade and Enterprise in Guatemala—* How to Build up Trade in Mexico—Durango's Iron Mountain—*American Goods in Honduras—Notes: Commercial Travelers in Honduras—Bank Wanted in Honduras.

Other Reports can be obtained by applying to the Department of Commerce and Labor, Washington, D. C.

TRADE NOTES AND RECIPES.

Ink for Writing on Celluloid.—

Ferric chloride	10 parts
Tannin	15 parts
Acetone	100 parts

Dissolve the ferric chloride in a portion of the acetone and the tannin in the residue, and mix the solutions.

Any pen may be used with the liquid.—Drug. Circ.

Preservative Fluid for Museums.—

Formaldehyde solution	60 grammes
Glycerine	120 grammes
Alcohol	30 grammes
Water	1,000 grammes

The addition of glycerine becomes necessary only if it is desired to keep the pieces in a soft state. Filtering through animal charcoal renders the liquid perfectly colorless. For dense objects, such as lungs and liver, it is best to make incisions, so as to facilitate the penetration of the fluid. In the case of very thick pieces, it is best to take 80 to 100 grammes of formaldehyde solution for above quantities.—Neueste Erfindungen und Erfahrungen.

Lanolin Hair Wash.—For a hair wash, which constitutes a substitute of the well-known "Javol" preparation, and excels the latter in appearance as well as by the use of a more suitable fat which does not turn rancid, Alfred Spindler gives the following receipts: Extract 4 parts quillaya bark with 36 parts water for several days, mix the percolate with 4 parts alcohol, and filter after having settled. Agitate 40 parts of the filtrate at a temperature at which wool grease becomes liquid, with 12 parts anhydrous lanolin, and fill up with water to which 15 per cent spirit of wine has been added, to 300 parts. Admixture, such as cinchona extract, Peru balsam, quinine, tincture of cantharides, bay-oil, ammonium carbonate, menthol, etc., may be made. The result is a yellowish-white, milky liquid, with a cream-like fat layer floating on the top, which is finely distributed by agitating.—Pharmaceutische Zeitung.

Liquid Antiseptic Soap.—According to Antoine, liquid antiseptic soap is obtained by means of the following receipt:

Caustic potash (70 per cent), free from carbonic acid, if possible	50 grammes
Sweet almond oil	200 grammes
Glycerine (30 deg. Bé.)	100 grammes
Distilled water to make up	1,000 grammes

Dissolve the potash in double the weight of water, add the oil and glycerine and stir. Next add the remainder of the water, and keep the mixture in the water bath at 60 to 70 deg. C. for 24 to 36 hours. Take off the unsaponified oil (consisting of oleic acid), thus obtaining a gelatinous mass; of this mix 900 grammes with 70 grammes of 90 per cent alcohol and 10 grammes each of lemon oil, bergamot oil, and verbena oil. Heat for a few hours to 60 deg. C., cool off, and filter off the eliminated potassium stearate needles by means of wadding. The filtrate remains clear. It contains from 0.8 to 1 gramme of free alkali to the kilogramme. This may still be neutralized by a current of carbonic acid or by tartaric acid-glycerine solution.—Pharmaceutische Centralhalle.

Bath-Tub Enamel Unaffected by Hot Water.—Nearly all the leading manufacturers of paints and varnishes make special hard-drying bath-tub enamels, which, if applied over a proper undercoat, will not soften or crack with hot water. But unless the metal surface is properly prepared, these defects may be looked for.

In order to make paint hold on the zinc or tinned copper lining of a bath tub, you need a wash to produce a film to which oil paint will adhere. First remove all grease, etc., with a solution of soda or ammonia and dry the surface thoroughly; then apply with a wide, soft brush equal parts by weight of chloride of copper, nitrate of copper, and sal ammoniac, dissolved in 64 parts by weight of water. When dissolved add one part by weight of commercial muriatic acid. This solution must be kept in glass or earthenware. It will dry in about 12 hours, giving a grayish black coating to which paint will firmly adhere.

The priming coat should be white lead thinned with turpentine, with only just sufficient linseed oil to bind it. After this is thoroughly dry, apply one or more coats of special bath-tub enamel, or a gloss-paint made by mixing coach colors ground in japan with hard-drying varnish of the best quality. Most first-class manufacturers have special grades that will stand hot water.—Drug. Circ.

To Bleach Ivory.—I. Wash the ivory well with ammonia water, then with water, and finally apply solution of hydrogen peroxide. II. Expose the ivory for three or four days to the action of sunlight, in a bath of turpentine oil. III. Treat the ivory alternately with a solution of potassium permanganate (1 in 250) and oxalic acid (1 in 100), letting the ivory remain in each solution for a half hour; then rinse well with water, and repeat the process a number of times. IV. Place the ivory in a hot mixture of undissolved lime, bran, and water; remove after a short interval, place in dry sawdust, and with the latter rub thoroughly; then expose to the air.

It seems not unlikely that the ivory after treatment by any bleaching process will require polishing. If so, and it is not deeply scratched, rub with a woolen cloth charged with a paste made from Armenian bole and oleic acid. Wash with castile soap, and, after drying, rub with chamois. A few wipes with an old silk handkerchief completes the gloss. If scratched, but not very deeply, smooth with a rouge cloth and proceed as above. If very deeply scatched it will be necessary to scrape with a very fine steel scraper (a sharp knife blade will answer) or broken glass, rub with rouge cloth until all scraper marks vanish, and finish as first directed. Curved or molded parts should be first scrubbed with an old stiff tooth-brush charged with the paste above mentioned, then with a soft brush charged with whiting and a little ammonia, and finally scrubbed with soap and water, and finished with chamois.—Drug. Circ.

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